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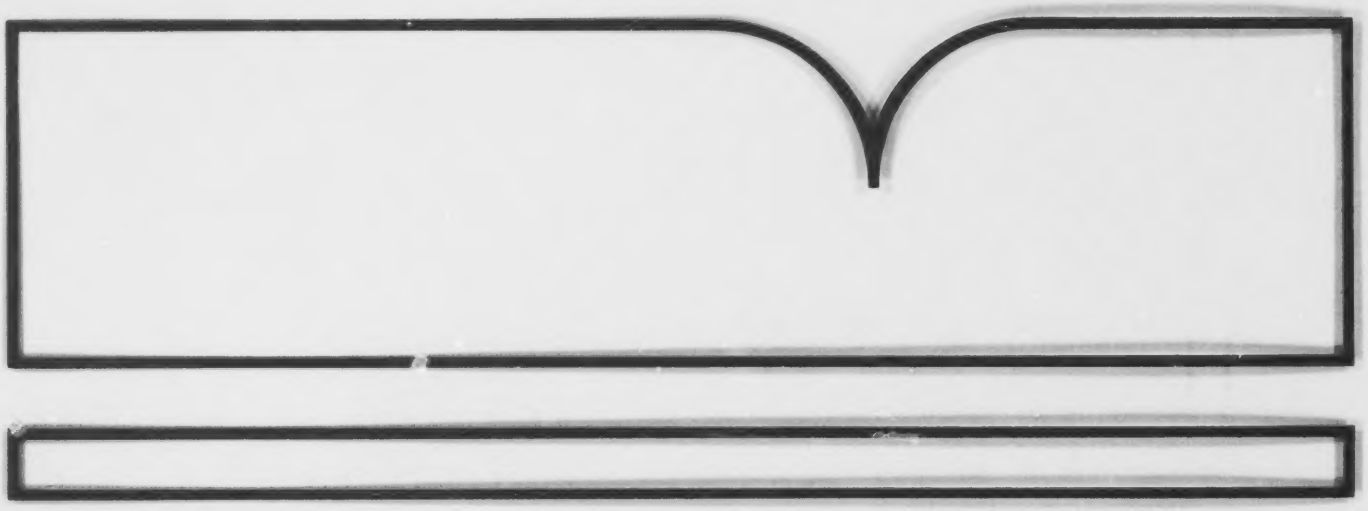
Love Canal Emergency Declaration Area Habitability Study. Volume 1 Introduction and Decision-Making Documentation

Life Systems, Inc., Cleveland, OH

Prepared for

Environmental Protection Agency, New York

May 88



U.S. Department of Commerce
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United States
Environmental Protection Agency

LOVE CANAL EMERGENCY DECLARATION AREA HABITABILITY STUDY

FINAL REPORT

VOLUME I

Introduction and Decision-Making Documentation

TECHNICAL REVIEW COMMITTEE

U.S. Environmental Protection Agency Region II
U.S. Department of Health and Human Services / Centers for Disease Control
New York State Department of Health
New York State Department of Environmental Conservation

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ICAIR, LIFE SYSTEMS, INC. and CH2M Hill Southeast, Inc.

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9. Performing Organization Name and Address

ICAIR, LIFE SYSTEMS, Inc.
24755 Highpoint Road
Cleveland, Ohio 44122

CH2M Hill Southeast, Inc.
P.O. Box 4400
Reston, VA 22090

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Environmental studies were conducted to provide data that could be used by the Commissioner of Health for the State of New York in determining whether the Emergency Declaration Area surrounding the Love Canal hazardous waste site is habitable. Volume I of the five-volume series summarizes the main elements and the key decision points in the Habitability Study as an introduction to the series.

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New York, New York 10278

Prepared by
ICAIR, LIFE SYSTEMS, Inc.
24755 Highpoint Road
Cleveland, Ohio 44122
Under Contract No. 68-01-7331

and

CH2M HILL SOUTHEAST, Inc.
P.O. Box 4400
Reston, Virginia 22090
Under Contract No. 68-01-7251

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The authors would like to acknowledge the efforts of all organizations and individuals who assisted in the conceptualization, design, and implementation of this study. Special acknowledgement goes to the U.S. Environmental Protection Agency Region II and the other members of the Technical Review Committee and their staffs for their continuing guidance.

LIST OF ACRONYMS AND ABBREVIATIONS

AALs	Acceptable Ambient Levels
ACGIH	American Conference of Governmental Industrial Hygienists
CDC	Centers for Disease Control
DHHS	U.S. Department of Health and Human Services
EDA	Emergency Declaration Area
EPA	U.S. Environmental Protection Agency
GC/MS	Gas Chromatograph/Mass Spectrometer
LCIC	Love Canal Indicator Chemical
NBS	National Bureau of Standards
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OTA	U.S. Congressional Office of Technology Assessment
ppb	Parts Per Billion
TAGA	Trace Atmospheric Gas Analyzer
TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
TLVs	Threshold Limit Values
TRC	Technical Review Committee

1.0 INTRODUCTION

This report is Volume I of a five-volume series. The objective of this report is to describe the main elements and key decision points in the Habitability Study of the Emergency Declaration Area (EDA) near the Love Canal Superfund site and to summarize the logic and rationale supporting the decisions made in the study. Most of this information has been documented in written reports from the Love Canal Technical Review Committee (TRC) and its contractors and has been presented and discussed at many public meetings. However, because this information is scattered among so many sources, trying to gain familiarity with the study and its logical basis from these sources would be a complex and time-consuming process. Thus, this report organizes and consolidates the key information needed to answer the questions "What was done, and why?"

This report is organized by subject matter and key decision point. The document does not trace the evolution of a concept or the strict chronology of each decision, unless this background is important to understanding the final decision. Rather, emphasis is placed on the final decision that was made and the rationale and logic supporting that decision. The presentation of information proceeds from general concepts and decisions to detailed issues required to implement the Habitability Study. Following the discussion of each major subject, a list of pertinent references is provided. References are coded by index numbers or acronyms, and these are defined in the back of the document in the References section.

Volumes II and III of this series present the results of the assessment for indicator chemicals for air and soil, respectively. Volume IV reports on the soil assessment for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), and Volume V summarizes the subsequent peer review of Volumes II, III, and IV and the responses to the peer review.

1.1 EARLY HISTORY OF THE LOVE CANAL SITE

Love Canal is a landfill site located in the southeastern corner of Niagara Falls, New York (Figure 1-1). Excavation of the Canal was begun in the late 1800s, with the aim of providing cheap, direct-current hydroelectric power

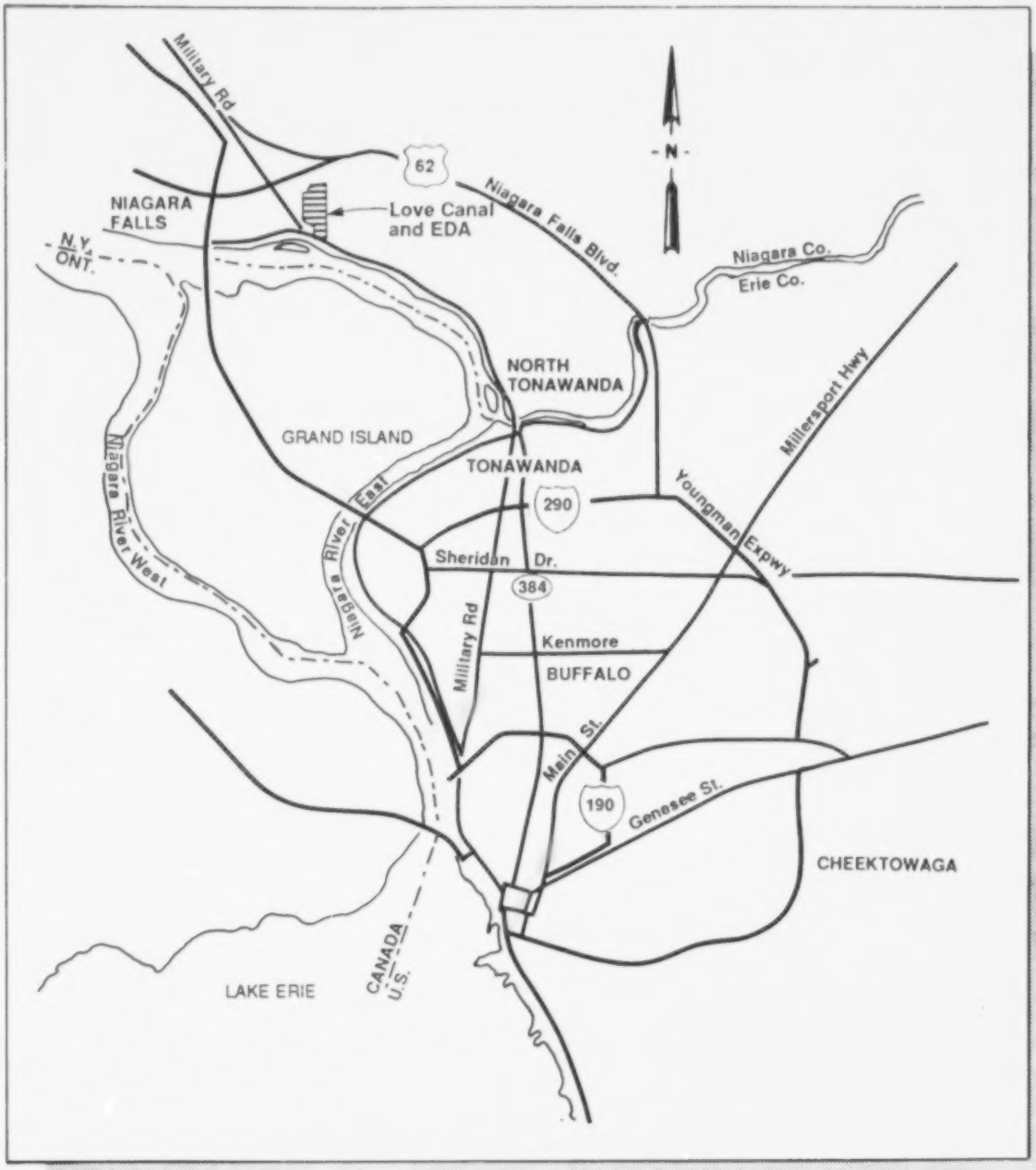

Figure 1-1
LOCATION OF
LOVE CANAL AND THE EDA

for proposed industrial facilities along its banks. However, the development of alternating current eliminated the need for industrial sites to be located close to power sources, so the partially dug Canal was abandoned, leaving a channel approximately 3,200 feet long and 80 feet wide. The exact depth of the original Canal is uncertain, but anecdotal information and current geophysical studies indicate the excavation was approximately 7 to 16 feet below grade.

From 1942 to 1953, the excavation became a chemical disposal site for the Hooker Electrochemical Company (now a subsidiary of Occidental Chemical Corporation). Hooker obtained title to the Canal in 1947 and sold the dump site to the Niagara Falls School Board in 1953 with a deed disclaiming responsibility for any injuries that might result from the buried waste. The City of Niagara Falls disposed of municipal wastes at the site from 1953 to 1954, after which time dumping ceased and the site was covered. Home building in the vicinity of the Canal accelerated, and the school board built a school on 99th Street near the middle portion of the site.

References for Section 1.1: 25 (Section 1.3), 27, 44, 45 (pp. 4-8), 64, 86 (Appendix 1)

1.2 ENVIRONMENTAL CONTAMINATION AND HUMAN HEALTH CONCERNS

During the years that followed, residents near the old Canal site began to complain of chemical odors, surface contamination, and injury to children and pets. By the mid-1970s there was increasing evidence that chemicals were leaking from the landfill, and analysis of sump samples in 1978 revealed significant levels of chemicals in eight homes abutting the Canal. Because of concern that these chemicals might pose a human health risk to some residents, most of the homes closest to the Canal (termed Rings I and II, as shown in Figure 1-2) were purchased from the residents on a voluntary basis in 1978. Subsequently, most of these homes were demolished, and a fence was erected around the perimeter of Ring II to enclose and restrict access to the site.

Concern remained, however, over health risks to residents beyond Ring II, and in 1980 President Carter determined that "...the adverse impact of chemical wastes in the Love Canal waste landfill...is of sufficient severity and magnitude to warrant an emergency declaration...." This declaration

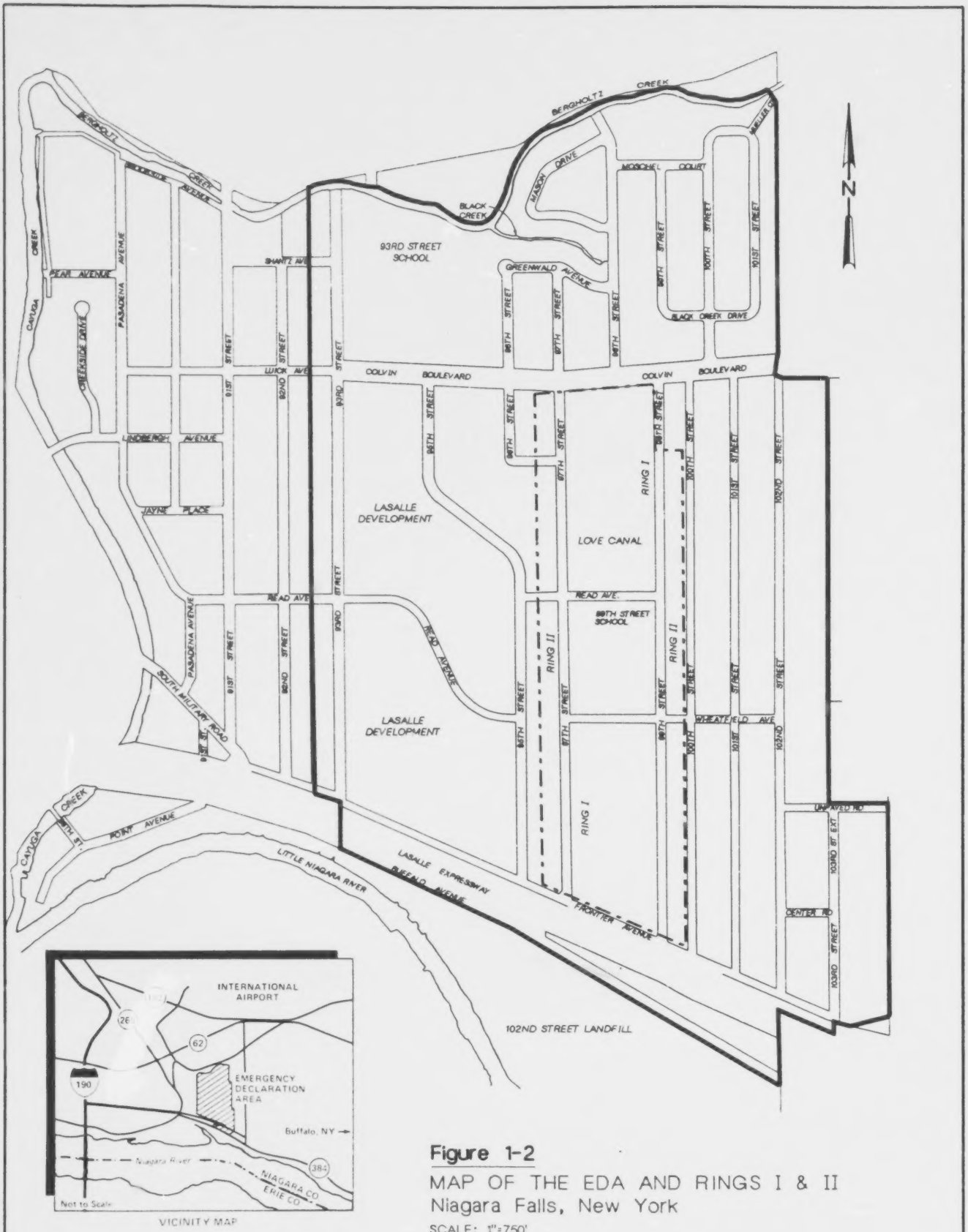

Figure 1-2

MAP OF THE EDA AND RINGS I & II
Niagara Falls, New York

SCALE: 1"=750'

LEGEND

EMERGENCY DECLARATION AREA (EDA) BOUNDARY

SOURCE:
EDA BOUNDARIES TAKEN FROM NEW YORK STATE REAL PROPERTY TAX LAW ARTICLE 17, SECTION 1702

followed release of a preliminary study that indicated some Love Canal residents may have suffered chromosomal damage because of exposure to toxic chemicals (a study that was later discredited). The area affected by the declaration was termed the "Emergency Declaration Area," and the boundaries were established as shown in Figure 1-2. Contained within these boundaries were about 650 private residential properties and about 300 public housing units. The Love Canal Area Revitalization Agency was established by the New York State Legislature and authorized to purchase the property of EDA residents who chose to relocate from the EDA.

References for Section 1.2: 16, 36, 40, 41, 42, 44 (pp. 6-11), 45 (pp. 8-16), 49, 51, 52, 56, 57, 58, 64, 65, 66, 67, 110, 111, PR-4 (Sect. 2.13.3)

1.3 REMEDIAL ACTIVITIES AT THE SITE

In October 1978, a program for the remediation of the Love Canal was initiated to reduce the environmental impact and potential health hazards associated with the chemicals in the dump site. Figure 1-3 summarizes the chronological relationship between the main elements of the remedial activities and other important events at Love Canal.

Remediation has progressed in three phases. Phase I activities took place from October 1978 to November 1979. The 99th Street School was closed, and more than 230 homes on 97th and 99th Streets adjacent to the Canal (Rings I and II) were purchased by the Government. The area encompassing the Love Canal, Ring I and Ring II south of Colvin Boulevard was enclosed by an 8-foot-high cyclone fence and posted to limit access. The 99th Street School as well as the homes within the fence were later demolished.

Phase I engineering work focused on containing the contaminants present at the site and limiting further discharges to the ground water, the surface water, or the atmosphere. To accomplish this, a barrier drain system was installed around the site to collect contaminated leachate. The leachate is pumped to a permanent, onsite treatment plant, which began operation in 1979. Treatment consists first of removal of the settleable solids and immiscible liquids, followed by filtration of suspended solids, and then by removal of organic contaminants from the aqueous phase in granular activated c arbon filters.

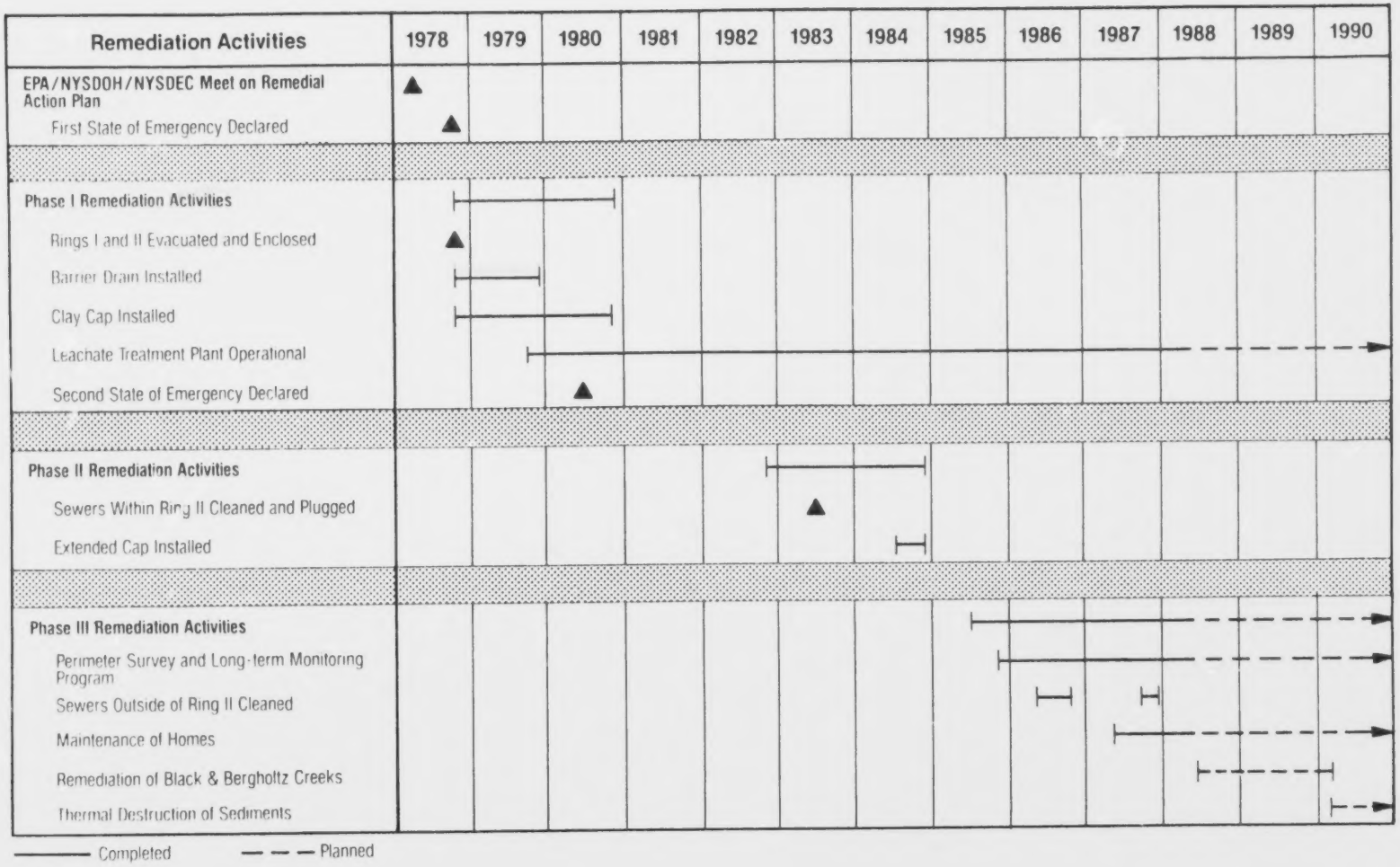

Figure 1-3
TIMELINE OF LOVE CANAL
REMEDIATION ACTIVITIES

The effluent, which is monitored each operating day, is discharged to the sanitary sewer system in accordance with the sewer use ordinance of the City of Niagara Falls.

In addition, the landfill was covered with a 3-foot-thick compacted clay cap to reduce infiltration of water from rain and snowmelt and to retard the formation of leachate and contaminated surface runoff. The cap also limits direct contact with the underlying contaminated soil as well as release of volatiles and contaminated fugitive dust from the surface.

Phase II remediation work was designed to enhance the effectiveness of the Phase I measures and was carried out from December 1982 to December 1984. To further reduce infiltration into the disposal area, a high-density polyethylene membrane was installed to cover nearly all the area inside the fence (a total of 40 acres). This membrane was covered with 18 inches of soil and planted with grass. The barrier drain system was cleaned and inspected and, where necessary, repaired. These Phase II activities collectively reduced the long-term costs of operation and maintenance of the leachate collection and treatment system.

Storm and sanitary sewers at the site were known to contain contaminated sediments and to serve as routes of contaminant migration to nearby creeks. As part of Phase II, sewers within Rings I and II were cleaned, plugged, and removed from further service. This action prevented the spread of additional contamination from man-made pathways into nearby creeks and the Niagara River.

The final phase of remediation (Phase III) is addressing areas affected by chemicals that had moved offsite into the EDA sewers and creeks. Sewer remediation has been completed, including the hydraulic cleaning of more than 65,000 linear feet of storm and sanitary sewers. The sewer sediments are currently stored onsite. Sediments contaminated with TCDD will be removed from nearby Black and Bergholtz creeks in 1989. A containment facility for the sewer and creek sediments and other onsite wastes will be constructed in the summer of 1988 at the Love Canal site. After appropriate testing of a transportable thermal destruction unit, these sediments and wastes will be destroyed onsite. This process is scheduled for completion by 1993. Also during this period, a decontamination/drum storage building will be constructed to provide year-round decontamination ability and a future drum management area.

Phase III also includes a perimeter ground water and soil survey and will include the implementation of permanent long-term monitoring programs to evaluate the continuing effectiveness of the Love Canal remediation program.

As of March 1988, over 90 percent of the private properties and the public housing units in the EDA were vacant, with about 60 residences and 15 rental units still occupied. Of the unoccupied residences, about 90 have been demolished because of deterioration, but the U.S. Environmental Protection Agency (EPA) and the New York State Department of Environmental Conservation (NYSDEC) have undertaken a stabilization program to maintain the remaining homes within the EDA until a habitability decision is made and implemented.

References for Section 1.3: 4, 14, 16, 18, 19, 26, 30, 35, 37, 39, 43, 44 (pp. 18-32), 45 (pp. 33-69), 62, 86 (Appendix 6), 97, 98, 99, 100, 102, 103, 104, 105, 106, 107, 108, 109, PR-1 (pp.415-474), PR-2 (Sect. 2.10), PR-3 (pp.77-85), PR-4 (Sect. 2.10.1), TRC (10/10/84 - Present), PR-5 (532-538), SRP (723-740, 801, 826, 1122-1146, 1331-1386, 1688-1783, 1809-1830, 1932, 1942, 1974-2072, 2128-2145)

1.4 THE 1982 DEPARTMENT OF HEALTH AND HUMAN SERVICES HABITABILITY RECOMMENDATION

One of the main reasons that the EDA was declared a potential human health risk in 1980 was the preliminary finding that residents of the EDA had an above-average frequency of chromosome damage. Serious questions were subsequently raised, however, about the validity and proper interpretation of these preliminary data. Based on the recommendations of a peer review panel, a second study of chromosome damage was designed and implemented by the Centers for Disease Control (CDC). This study was carefully planned to incorporate optimal case-control matching procedures, sample collection methods, and data analysis techniques. The study did not detect any significant difference in the frequency of chromosome damage between residents of the EDA and people living in other locations.

This result called into serious doubt one of the main reasons for declaration of an emergency and evacuation of the EDA and raised the issue of whether

the EDA was suitable for rehabitation. The EPA requested that the Department of Health and Human Services (DHHS) address this question and provided the DHHS with the results of an extensive environmental chemical testing program that the EPA had begun in 1980. This program involved analyzing samples of air, water, sediment, soil, and biota for a wide range of chemical pollutants. Altogether, more than 6,000 samples were analyzed.

After an initial review of the data, the DHHS asked the National Bureau of Standards (NBS) to evaluate the analytical procedures employed by the EPA. Based on the NBS finding that the methods were appropriate, the DHHS then sought to answer the following questions:

1. Are the concentrations of chemicals measured in the EDA significantly different from levels found in other areas of Niagara Falls?

2. Do the levels measured represent concentrations that could cause acute or chronic adverse health effects in people living in the Love Canal area, beyond what might be expected under usual residential conditions in the Niagara Falls area?

3. Were sufficient samples taken and analyzed to determine the extent of contamination by particularly hazardous materials and to be able to assess their potential threat to human health?

4. Based on the available data, can it be concluded that the area is not habitable?

Based on their review of the EPA data, DHHS reached the following conclusions, with which the New York State Department of Health (NYSDOH) concurred:

1. Concentrations of chemicals in the EDA (excluding storm sewers) were comparable to levels detected in control areas elsewhere in Niagara Falls. Increased concentrations were present at the Canal itself and in some homes abutting it, as well as in material from storm sewers at many points in the area.

2. Concentrations of chemicals in air, water, and soil in the EDA (excluding storm sewers) were well below established regulatory or advisory exposure limits for those identified chemicals where guidelines exist and, by inference, for closely related compounds. In this context, the

levels detected were judged not to present risks to human health different from those in the control areas in Niagara Falls. However, complete judgments of the potential adverse health effects could not be made since official safety limits did not exist for all possible chemicals, and those that did exist were developed for exposure to single chemicals alone, not for combinations of chemicals.

3. Environmental samples obtained and analyzed by EPA were sufficient for numerical comparisons between declaration and control areas, although the materials supplied to DHHS did not allow an assessment of the adequacy of the sampling plan or the statistical power of the study.

4. The Love Canal EDA was as habitable as the control areas to which it was compared. This decision was contingent on the provision that the sewers and their drainage tracts be cleaned and that continuous safeguards be observed to prevent further leakage from the site.

References for Section 1.4: 10, 17, 23, 27, 28, 29, 31, 39, 53, 54, 55, 59, 60, 70, PR-3 (pp.158-189), SRP (13-16)

1.5 THE 1983 OFFICE OF TECHNOLOGY ASSESSMENT RESPONSE

In December 1982, the Congressional Office of Technology Assessment (OTA) was requested to review the technical basis for and the validity of the conclusions by DHHS regarding the habitability of the EDA. In June 1983, the OTA reported that, based on available information, it was not possible to conclude whether or not unsafe levels of toxic contamination existed in the EDA. The OTA further concluded that the analysis of available data did not support the decision by DHHS that the EDA was as habitable as the control areas to which it was compared. The OTA had three major criticisms of the study:

- The EPA monitoring study was not designed for a comparison approach; therefore, the choice of comparison areas was not necessarily appropriate nor were sufficient samples obtained from the comparison areas to permit a valid comparison.

- The number of samples with nondetectable concentrations made a statistical comparison of the EDA with the comparison areas difficult.

- The EPA study contained important uncertainties over the levels of the toxic chemicals detected and the possible levels of those not detected.

The OTA pointed out that one of the major shortcomings of the approach followed by EPA and DHHS was that specific criteria for determining habitability were not developed prior to the collection and evaluation of data. Consequently, OTA indicated the need to demonstrate more unequivocally that the EDA was safe both immediately and over the long term. Otherwise, OTA concluded it might be necessary to accept the original presumption that the EDA is not habitable.

References for Section 1.5: 29, 63, PR-3 (pp. 190-191), SRP (13-16)

1.6 FORMATION OF THE TRC

In August 1983, the EPA established the Love Canal TRC to act as a management group to provide interagency coordination and oversight for the many matters related to the Love Canal site. The TRC comprises senior-level representatives from EPA, the CDC/DHHS, NYSDOH, and the NYSDEC. Table 1-1 lists the lead representatives from each agency and their times of service on the TRC.

The principal task that the TRC undertook was to consider the issue of habitability of the EDA. The TRC asked the CDC and the NYSDOH to develop habitability criteria that could be applied to the EDA and that, if met, could be used by the Commissioner of Health for the State of New York to determine the habitability of the EDA.

To assure that the criteria would be reasonable, practical, and scientifically sound, the CDC and NYSDOH sought the advice of scientists from a variety of disciplines, along with the suggestions and recommendations of representatives of industry, other government agencies, and the public. A summary of the process by which the Habitability Study was planned, reviewed, and performed is provided in Section 2.0.

Table 1-1
REPRESENTATIVES OF TRC AGENCIES

Agency	Representative	Years of Service
EPA	Mr. William Librizzi, Director, Emergency and Remedial Response Division, EPA Region II, New York, NY (Chairman)	1983--1986
	Mr. Kenneth Stoller, Deputy Director, Emergency and Remedial Response Division, EPA Region II, New York, NY (Chairman)	1986--1988
	Mr. Steven Luftig, Director, Emergency and Remedial Response Division, EPA Region II, New York, NY (Chairman)	1988--Present
DHHS/CDC	Mr. Daniel Van der Meer, Associate Director, Center for Environmental Health, Centers for Disease Control, U.S. Department of Health and Human Services, Atlanta, GA	1983--1986
	Dr. John Liddle, Center for Environmental Health, Centers for Disease Control, U.S. Department of Health and Human Services, Atlanta, GA	1986--Present
NYSDOH	Dr. Robert Huffaker, Associate Director, Office of Public Health, New York State Department of Health, Albany, NY	1983--1986
	Dr. William Stasiuk, Director, Center for Environmental Health, New York State Department of Health, Albany, NY	1986--Present
NYSDEC	Mr. Norman Nosenchuck, Director, Division of Solid and Hazardous Waste, New York State Department of Environmental Conservation, Albany, NY	1983--1988
	Mr. Michael O'Toole, Acting Director, Division of Hazardous Waste Remediation, New York State Department of Environmental Conservation, Albany, NY	1988--Present

References for Section 1.6: 71, 73, 86 (pp. 1-4, Appendix 2), 115, PR-3 (pp. 191-196), SRP (1-12, 1009-1011), TRC (12/14/83, 04/23/84)

2.0 THE HABITABILITY ASSESSMENT PROCESS

2.1 THE ROLE OF THE TRC

The Love Canal TRC was organized in August of 1983 to provide coordination and technical oversight of both remedial actions at the Love Canal site and efforts to assess the habitability of the Love Canal EDA. This document and its four companion volumes focus on the habitability study and TRC efforts to provide review and guidance for scientific and technical excellence, public participation, and an integrated multiple-agency approach.

Throughout the habitability assessment process, specialized groups and individuals were used, including chemists, statisticians, soil scientists, air monitoring experts, computer scientists, field samplers, and community relations experts. In addition, the TRC convened two panels of scientists to review the work conducted to date. A third panel was established to review Volumes II through IV. A summary of their review and responses to peer review comments can be found in Volume V.

Public involvement in the habitability assessment evolved into an active program with public TRC meetings held every 4 to 6 weeks. All major TRC decisions were preceded by opportunities for public comment and discussion of their concerns. Additional aspects of this unique public participation program are discussed in a later section.

As a result of active TRC oversight and public participation, the habitability assessment process has been an integrated, multiple-agency undertaking. The process has resulted in a project that has the general support of the four TRC agencies and the public.

References for Section 2.1: 86, 73

2.2 DEVELOPMENT OF THE HABITABILITY CRITERIA

One of the first and most important tasks undertaken by the TRC was to develop criteria to be presented to the Commissioner of Health for the State of New York for use in a determination of the habitability of the EDA. The development of habitability criteria as the initial step in the habitability assessment of the EDA was the primary responsibility of NYSDOH and CDC. The TRC obtained the services of 10 distinguished scientific advisors to assist in the development of the habitability criteria. From March 1984 to March 1985, the scientists met seven times at Niagara Falls in public sessions to develop the initial concepts for the habitability criteria.

The scientific advisors reviewed the existing environmental data, the remedial measures, and the published and unpublished health studies. Concurrently, they also considered several possible approaches to use as the basis for the habitability criteria. The approaches considered and the rationale for their acceptance or rejection are discussed in Section 3.0.

After several meetings, the scientific advisors recommended an approach for the habitability criteria that uses a combination of relevant Federal and New York State standards, criteria, or guidelines for residential purposes (where they exist) and a comparison of levels of select Love Canal Indicator Chemicals (LCICs) in the EDA with levels of the same chemicals from areas similar to the EDA, but not near a chemical landfill. The basic concept of the comparison approach assumes that "data collected from the comparison areas will correspond to 'normal' or habitable conditions." When these data are compared to similar measurements in the EDA, they will provide an indication of whether or not the concentrations of air LCICs in the EDA homes and soil LCICs in the EDA neighborhoods are significantly different from those in the comparison areas. If the concentrations of the LCICs in the EDA are significantly greater than those of the comparison areas, the source of the chemicals will be assumed to be the Love Canal.

The intent of the recommended approach is to determine if the chemicals from Love Canal have reached the EDA in sufficient quantity to create a significant difference between the concentration of the LCICs in the EDA and the concentration in the comparison areas. This approach purposely does not assess the health impacts of the Love Canal on the EDA.

This basic approach to determining habitability was further developed by NYSDOH and CDC staff through nine drafts of the habitability criteria. The first draft was issued in 1984, and the final document, *Love Canal Emergency Declaration Area: Proposed Habitability Criteria*, was released in December 1986. Issues that received particular attention and that are addressed in subsequent chapters include the determination of the applicable Federal or New York State standards, criteria, or guidelines that apply to the EDA, the selection of the comparison areas, the choice of media to sample, the selection of LCICs, the determination of what constituted a "significant difference," and the identification of the ways in which air sampling in individual homes would be used in conjunction with soil sampling for EDA neighborhoods. Each draft was reviewed by the scientific advisors, the public, the TRC agencies, and the contractors retained by the TRC.

References for Section 2.2: 86, SRP

2.2.1 Summary of the Draft Proposed Habitability Criteria

The habitability criteria called for three environmental sampling studies. The air assessment for LCICs, Volume II, was to be designed to compare the results of indoor air samples from occupied residences in the EDA with indoor air samples from occupied residences in the comparison area. Air samples from unoccupied EDA residences were to be compared with ambient air samples taken from the EDA. The soil assessment for LCICs, Volume III, was to be designed to compare concentrations of LCICs in EDA neighborhoods (13 neighborhoods were defined in the habitability criteria) with concentrations of LCICs in a comparison area (the criteria specified how these areas were to be selected) to determine if the EDA neighborhoods were significantly different from the comparison neighborhoods. The soil assessment for dioxin, Volume IV, was designed to determine if the EDA soils had concentrations of TCDD greater than the 1 part per billion (ppb) Federal level of concern.

The draft criteria stated:

A neighborhood in the EDA is considered habitable if all three of the following conditions are met:

1. If soil sample measurements of TCDD are less than 1 ppb; and,

1. If soil sample measurements of TCDD are less than 1 ppb; and,

2. If the chosen aggregate values (e.g., mean, median, percentiles, etc.) of each non-TCDD LCIC evaluated both individually (univariate) and collectively (multivariate) are not significantly different than the values from the comparison areas; and,

3. If the integrity of the neighborhood with reference to the habitability of individual homes within it and to its location relative to other neighborhoods (habitable or uninhabitable) is maintained.

Residences in the EDA will be sampled for air LCICs. A residence in the EDA is considered habitable if all three of the following conditions are met:

1. If it is located in a neighborhood judged to be habitable; and,

2. If the results of the air comparisons show that retesting and/or remediation are not necessary; and,

3. If remediation is performed and is shown to be successful. Remediation will be considered successful if LCICs are reduced to the same levels as found in habitable areas.

Remediation would be called for if an EDA residence had a significantly higher LCIC concentration than found in the comparison area residences.

In addition, the habitability criteria required that the previously taken remedial actions effectively contain the wastes stored in the Canal, that remediation of the sewers be conducted, and that an acceptable remedial plan for the creeks be established.

References for Section 2.2.1: 86

2.2.2 Peer Review of the Habitability Criteria

Prior to finalizing the habitability criteria, the TRC convened a panel of 10 scientists for a peer review of the November 1985 draft of the habitability criteria. The peer review panel was charged with determining whether the approach and criteria described in the proposed habitability criteria were reasonable, practical, and based on sound scientific principles. The major

areas of scientific expertise that were required to perform a comprehensive peer review of the habitability document were identified, and reviewers were selected to provide expertise in the required subject areas. The peer review panel assembled in Niagara Falls and met in public sessions from March 12 through 14 to debate the issues of concern. A report summarizing the main discussions and recommendations was submitted to the TRC and the public on April 25, 1986. On May 12 and 13, 1986, the peer review panel reconvened to hear comments and questions from the public. Following the meeting, written responses to each comment were drafted, approved by the panel, and documented in a report.

The peer review panel concluded that the overall approach proposed by the Habitability Criteria document was reasonable, practical, and based on sound scientific principles. There was a general agreement among reviewers in their analysis of and opinions on most aspects of the proposed approach. The reviewers offered a number of recommendations and suggestions regarding the sampling and analysis plan and the statistical analysis procedure. Significant discussion among the reviewers focused on two aspects of the approach, both related to the number and types of chemicals to be considered in the comparisons.

Changes incorporated into the criteria document resulting from the peer review process involved adding the following:

- A preface that defined the sequence of future actions in the habitability assessment process
- More justification for both the type of media and the chemicals selected for environmental sampling
- The option to redefine neighborhood boundaries at the completion of the study
- The criteria for successful remediation of measured levels of contamination in sampling media

References for Section 2.2.2: PR-1 through PR-4

2.3 IMPLEMENTATION OF THE HABITABILITY CRITERIA

The habitability criteria required two initial implementation steps to be taken. The first was selecting the comparison areas as specified in the habitability criteria. This selection was completed by NYSDOH in October 1986 after a thorough review of candidate sites and a tour of proposed sites by the public. Section 6.3, Selection of Comparison Area, describes this process in more detail. The areas selected were neighborhoods in the towns of Tonawanda and Cheektowaga. The second step was to conduct pilot studies for the air and soil comparison studies. After these initial steps were completed, the habitability study was conducted.

References for Section 2.3: 86

2.3.1 Pilot Studies

Prior to the start of habitability sampling, pilot studies for the soil and air comparisons were required. The purpose of the pilot studies was to test the feasibility of implementing the habitability criteria and to develop data that could be used to:

- Test the sampling and analytical methods proposed for the comparison studies
- Provide preliminary data on the levels and statistical distributions of the LCICs
- Provide a basis for determining the number of samples that needed to be taken to produce statistically valid results for the comparison studies

The results of the air and soil pilot studies are reported in *Pilot Study for Love Canal EDA Habitability Study*, Volumes I and II. Based on the findings of the soil pilot study, NYSDOH conducted a small follow-up study that collected soil samples from areas within the EDA, Cheektowaga, Niagara Falls, and the town of Wheatfield. This study was conducted to evaluate potential non-Love Canal sources for some of the LCICs. The reasons for and the results of this study are reported in Volume II of the pilot study report.

The pilot study reports underwent peer review from March through May 1987 with a 3-day public meeting held from March 24 through 26. The peer reviewers included some members from the previous panel, which had reviewed the habitability criteria, as well as some new members.

The major changes in the soil LCIC assessment that resulted from the pilot study and the peer review were:

- The analysis for semivolatile compounds only
- The consideration of two additional comparison areas, both from Niagara Falls
- The combination of the 13 EDA neighborhoods into a smaller number of sampling areas for purposes of the statistical design and analysis of the soil LCIC data

The major changes in the air LCIC assessment that resulted from the pilot studies and the peer review were:

- The combination of the two isomers of the same compound (chlorotoluene) into a measurement of total chlorotoluene concentration (a shift from three to two air LCICs)
- The consideration of any detectable air LCIC concentration as significant, which resulted in the air in the comparison areas not being sampled

References for Section 2.3.1: 79, 81, 84, 85, 95, PR-5, PR-6

2.3.2 Habitability Study

The habitability study consisted of the air LCIC comparison study, the soil LCIC comparison study, and the soil dioxin study. Many of the steps of the three studies were similar and included:

- Developing and testing sampling and analytical protocols
- Obtaining permission to sample
- Preparing a sampling plan
- Preparing the Quality Assurance Project Plan
- Collecting and analyzing the samples

- Validating the sample results
- Evaluating the data
- Preparing reports

The air LCIC comparison study collected indoor air samples from 562 residences during four sampling periods in 1987. During the air comparison study, special attention was paid to developing protocols to track the source of an LCIC should a detectable concentration be found in a residence. The sampling plan was also designed to evaluate potential seasonal and diurnal variation in concentrations of LCICs.

The soil LCIC study was conducted in October and November of 1987. The sampling design was carefully planned using a randomization concept so that the comparison statistics could be properly performed at the end of the study. A total of 879 soil samples were collected and sent for analysis. The study required the development of an analytical method capable of detecting the LCICs at levels as low as 0.2 ppb. After the method was developed, analytical laboratories were selected and trained in the use of the method. The quality of the laboratories' work was closely monitored by an extensive quality control program overseen by the EPA Office of Research and Development.

A total of 2,274 soil dioxin samples were collected during three sampling periods, one in late 1986 and two in 1987. Samples were collected using a combination of a statistically based "hot spot" sampling design and a TRC directive to collect two samples per residential lot. The samples were analyzed by laboratories in EPA's Contract Laboratory Program and validated by EPA Region II staff.

A peer review of Volumes II, III, and IV of this report is an integral part of the implementation of the habitability study. The results of the peer review are reported in Volume V.

References for Section 2.3.2: 89, 90, 91, 92, 93, 94, 95, 96

2.3.3 Habitability Decision

In accordance with the Habitability Criteria document, Volumes I through V will be presented to the Commissioner of Health for the State of New York for use in a determination of habitability.

Section 312(e) of the Federal Superfund Amendment and Reauthorization Act requires the Administrator of EPA to conduct or cause to be conducted a habitability and land use study. The study:

1. Assesses the risks associated with inhabiting the Love Canal EDA

2. Compares the level of hazardous waste contamination in that area to that present in other comparable communities

3. Assesses the potential uses of land within the EDA, including but not limited to residential, industrial, commercial, and recreational uses as well as the risks associated with such potential uses

The Act also requires the Administrator to publish the findings of such a study (this five-volume report) and to work with the State of New York to develop recommendations based on the results of the study.

Since both the habitability criteria and the Superfund Amendments recognize that decisions on land use are ultimately related to decisions on habitability, the Commissioner will convene a panel representative of community interests to advise him on future land uses for the EDA. The Commissioner will consider the advice of the panel and include in his decision on habitability recommendations for implementing that decision.

This local advisory panel will be convened shortly after transmittal of Volumes I through V of this report. It is anticipated that the Commissioner's determination on habitability of the EDA and recommendations for the implementation of his findings will take approximately 3 months following receipt of the report. The process will conclude with the Commissioner's transmittal of his determination and recommendations to the Administrator of EPA.

References for Section 2.3.3: 116, TRC

2.4 PUBLIC PARTICIPATION

There has been a long history of public involvement at the Love Canal site, and the public has been actively involved in deliberations associated with the Love Canal Habitability Study. In March of 1983 the NYSDEC established a Public Information Office at the Love Canal. This office is staffed by two full-time NYSDEC personnel and serves as a document repository for all Love Canal-related materials. When the TRC was established in August of 1983, the Public Information Office also became the repository for all significant records associated with the activities of the TRC. This local presence has provided immediate public access to all significant documentation associated with Government decision-making related to the Love Canal site. In addition, EPA also has a Niagara Falls Public Information Office which informs the public of activities related to Love Canal as well as activities related to the Agency's other environmental programs.

The formation of the TRC resulted in requests from the public to participate in the process in an active and purposeful manner. In response to these requests, the TRC asked the community to recommend two independent scientific advisors to assist NYSDOH and CDC in the development of the habitability criteria. Although the community had divergent opinions on the activities associated with the Love Canal site, a Love Canal Coalition, which was representative of all community organizations at the Love Canal site, was formed to respond to this request. After numerous meetings and discussions, the coalition selected a list of scientists, which was submitted to the TRC for consideration. Two of these scientists were asked to participate as scientific advisors in the development of the habitability criteria.

In the interim, the TRC presented four options for public participation and requested the community to select an approach. In addition, the coalition developed its own 12-Point Plan for Public Participation. One significant recommendation by the coalition was that the TRC hold all of its meetings in a public location easily accessible to the Love Canal community. As a result of discussions with the Love Canal Coalition on the 12-Point Plan, the TRC made the decision to hold meetings in public at Niagara Falls, but retained the right to hold executive sessions as necessary. Although the first meeting of the scientific advisors was held in Buffalo, all subsequent meetings of the advisors and the TRC have been held in Niagara Falls.

During these open TRC meetings, opportunities for dialogue between the TRC representatives and the community were provided for each major agenda item. While the agenda focused on the habitability assessment, NYSDEC also provided periodic updates on the remedial program. (In addition, the NYSDEC continued its more extensive public participation efforts for the individual projects in which it was involved through the Public Information Office.) This forum gave the public an opportunity for immediate input into the decision-making process and for further discussion on items of concern. Public comment periods on all significant documents were provided prior to the finalization of these documents.

The TRC also provided a forum for the community to discuss issues not directly related to the habitability study or the remedial program. Representatives of the TRC often interceded with Government agencies on behalf of the local community. Attempts were frequently made by the TRC to resolve problems that occurred within the Love Canal EDA, even if the problems were outside the direct jurisdiction of the TRC agencies.

The NYSDOH also worked closely with the community in the selection of the comparison areas. Residents and Government representatives traveled together by minibus to each of the potential comparison areas and reviewed them for comparability to the EDA. The comparison areas were selected after the results of the joint community/Government review were considered.

An extensive community outreach program was implemented by the NYSDOH to encourage Love Canal EDA and comparison area property owners to participate in the environmental sampling necessary to complete the habitability study. The schedule of sampling events was modified to meet the needs of residents, ample notice of entry onto each property was provided, and other conditions required by the property owners were accommodated to the degree possible.

References for Section 2.4: 71, 73, TRC

2.5 SUMMARY

In accordance with the habitability criteria document, the results of this study will be presented to the Commissioner of Health for the State of New York

for use in a determination of habitability. The habitability study followed the guidelines set forth in the habitability criteria. The development of the criteria and their implementation took more than 4 years. Figure 2-1 shows a timeline of the major activities of this process. Throughout the development and implementation of the habitability criteria, the TRC and the public have worked closely to assure that the highest technical standards have been met.

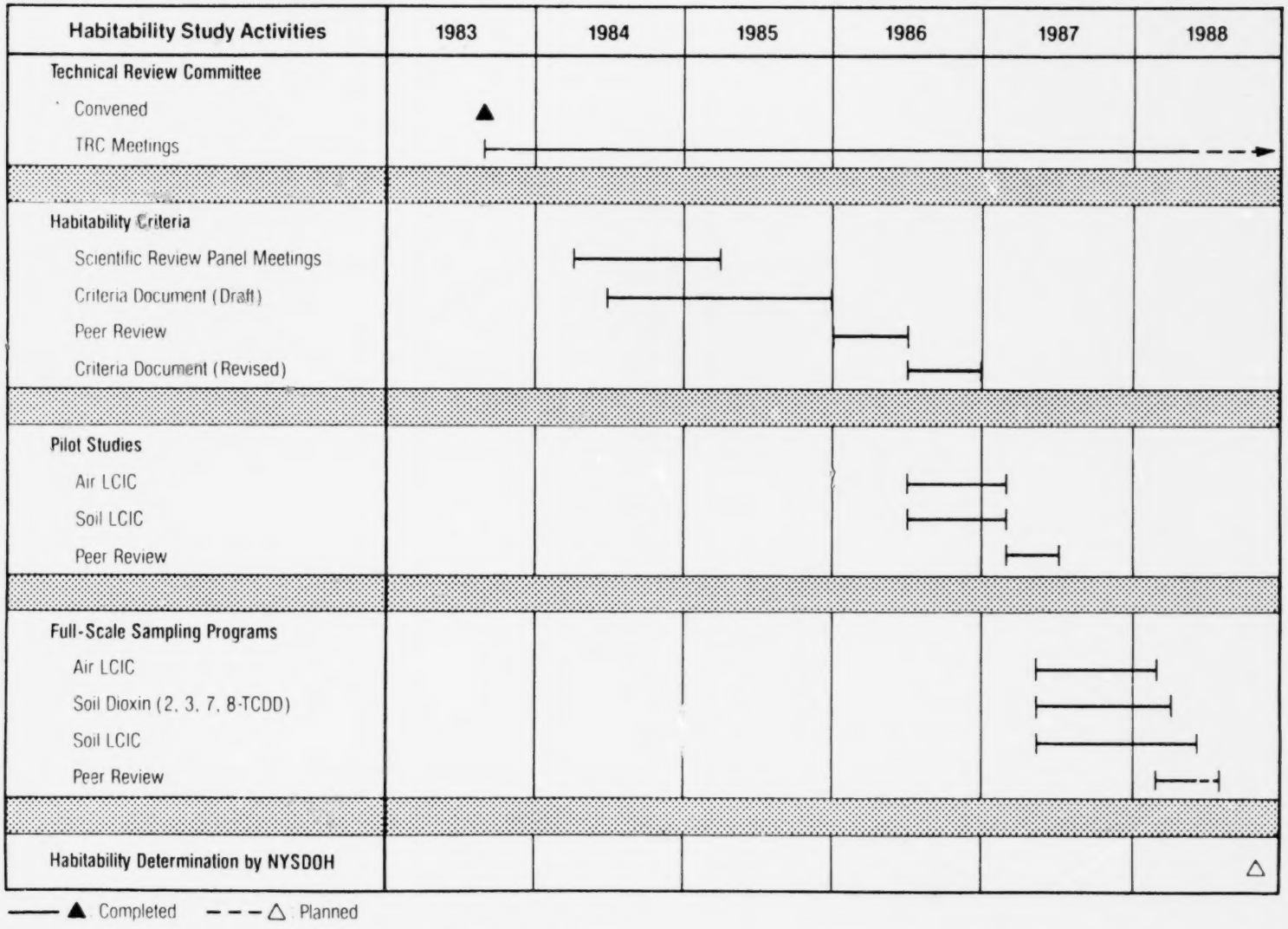

Figure 2-1
TIMELINE OF LOVE CANAL
HABITABILITY STUDY ACTIVITIES

3.0 FUNDAMENTAL CONCEPTS AND OBJECTIVES

The fundamental approach to the Habitability Study was to derive a set of criteria for judging the suitability of the EDA for human habitation and to obtain a data set adequate to satisfy the requirements of the criteria. To guard against reaching an ambiguous result, it was stipulated that the criteria must meet three requirements:

- The criteria must apply to the EDA and may or may not be applicable elsewhere.
- The criteria must be as objective, quantifiable, and reproducible as possible.
- The criteria must lead to a "yes" or "no" answer.

Before work began on development of the habitability criteria, it was necessary to define the concept of habitability and to identify the principal determinants of habitability in the EDA. These issues are described below.

3.1 DEFINITION OF HABITABILITY

For purposes of the task at hand, "habitable" means suitable for human habitation, including all ages and both sexes (including pregnant women) engaged in normal activities. In most situations, including that of the Love Canal EDA, judgments about suitability for human habitation rarely involve a simple yes/no response. Important considerations include the degree of certainty about the presence or absence of risks and whether these risks are immediate or delayed, serious or negligible, voluntary or involuntary, and whether restricted habitability or alternative land use is intended. With regard to the Love Canal EDA, the judgment is also complicated by the fact that some residents of the EDA were offered temporary relocation pending an official judgment on the risks posed by the presence of the Love Canal disposal site. This, compounded with the publicly voiced critiques (whether justified or not) of the existing exposure and health assessment data of Love

Canal, has created questions in the community concerning the risks posed by rehabitation of the Love Canal EDA.

If the EDA is found to be suitable for human habitation, then other land uses (e.g., public park, business area, churches) will also be acceptable. If the EDA is judged to be unsuitable for full-time and unrestricted human habitation, then other possible uses will be evaluated as specified under the Superfund Amendments and Reauthorization Act. It is expected that the data collected for the Habitability Study will be adequate for use in any alternative land-use assessment.

References for Section 3.1: 53 (pp. 3-4), 86 (pp. 4-5, Appendix 4), 112, 116, PR-1 (pp. 27-34), PR-2 (Sect. 2.2), PR-4 (Sect. 2.12.1), SRP (4-10, 92-94, 320-323, 532-545, 664-668, 1149-1170), TRC (01/14/88)

3.2 CONSIDERATION OF "BACKGROUND" CHEMICALS

Any chemical contaminants present in the EDA may have migrated or been transported there from Love Canal, or they may have reached the EDA from sources other than the Canal. Other sources could include emissions from nearby industries, emissions from vehicle traffic, pesticide products applied to lawns or shrubs, and so on. In considering the scope of the Habitability Study, it was therefore necessary to choose between two basic alternatives:

1. Evaluate the habitability of the EDA in terms of the total amount of all chemicals present, regardless of their origin.

2. Evaluate the habitability of the EDA on a relative basis, seeking to determine if migration or transport of chemicals from Love Canal has resulted in any significant increase in chemical levels in the EDA.

In considering these two approaches, it was presumed that the EDA would be considered habitable if it were certain that there was no chemical contamination present from Love Canal. Consequently, the critical issue was judged to be whether or not chemicals from Love Canal had reached the EDA, and not whether any other chemicals were present as a result of emissions from other sources. Moreover, any assessment based on the total of all chemicals present would require generation of standards or guidelines by

which to judge acceptable environmental levels. However, this is an extremely slow and costly process, which was neither feasible nor appropriate, since the setting of standards and guidelines requires proper legislative mandate and review. For these reasons it was concluded that the Habitability Study should be based on a consideration of chemicals from the Love Canal waste site only. To the extent that any concern might exist regarding background or ambient pollutants, that concern remains the proper responsibility of the appropriate local, State, or Federal agencies.

References for Section 3.2: 75, PR-1 (pp. 38-63, 323-325, 361-366), PR-2 (Sect. 2.1, 2.3), PR-3 (pp. 25-56, 94-116), PR-4 (Sect. 2.1.1, 2.4.7, 2.5.7, 2.6.6, 2.6.7, 2.8.2, 2.9.1, 2.12.3), SRP (1149-1170, 1659-1660, 1678-1687)

3.3 EVALUATION BY RESIDENCES AND NEIGHBORHOODS

The EDA is a large area, and a priori it was considered plausible that variations across the EDA might lead to the finding that some portions of the EDA were habitable while others were not. Consequently, it was judged appropriate to deal with these potential variations in an open and flexible way, rather than on an all-or-nothing basis. For this reason, the smallest unit of the habitability assessment was taken to be an individual residence. However, the suitability of an individual residence also depends on social factors such as the distribution of habitable and nonhabitable residences nearby. That is, a habitable residence surrounded by nonhabitable residences might lack the necessary contiguous habitable space required for a suitable residence. Consequently, it was concluded that the Habitability Study should contain an evaluation of the EDA by neighborhoods as well as by individual residences.

References for Section 3.3: 86 (pp. 18-22, Appendix 8), PR-1 (pp. 37-38), PR-2 (Sect. 2.9), PR-4 (Sect. 2.9.1), SRP (557-559, 695-696, 927-929, 1267-1274, 1431-1432, 1784-1796, 1833-1855, 1925-1929)

3.4 SUMMARY

Based on the considerations described above, the objectives and scope of the Habitability Study were articulated as follows:

> The proposed habitability criteria are designed to yield information necessary to answer this question: Does the Love Canal hazardous waste disposal site (in its present state of remediation and with the guarantees of EPA and NYSDEC for continuous monitoring and containment) have a measurable impact on the environment of the Emergency Declaration Area (EDA) which, in the judgment of the New York State Commissioner of Health, renders the entire Emergency Declaration Area or neighborhoods in the EDA not habitable from a public health standpoint? (Source: Love Canal Emergency Declaration Area Proposed Habitability Criteria: December, 1986)

4.0 SELECTION OF THE BASIC APPROACH TO EVALUATE HABITABILITY

A number of approaches were considered for assessing the habitability of the EDA. Presented below is a summary of each approach that was considered, along with an evaluation of the approach in terms of the general objectives and requirements described in Section 3.0.

4.1 APPLICATION OF RELEVANT STANDARDS, CRITERIA, OR GUIDELINES

The EDA cannot be recommended for habitation if the concentrations of any chemical in the environment of the EDA exceeds a relevant Federal or New York State standard, criterion, or guideline. Consequently, comparison of chemical levels in the EDA to relevant standards, criteria, or guidelines was selected as the most appropriate first step in the Habitability Study. Because the goal is to safeguard residents of the area, "relevant" in this case is taken to mean that the standard, criterion, or guideline is intended to apply to the conditions of residential exposure typical in the EDA.

References for Section 4.1: 51 (pp. 8-11), 86 (pp.7-8, Appendix 7, pp. 7-8 to 7-11), 87, 101 PR-1 (pp. 227-268), PR-2 (Sect. 2.1, 2.3), PR-3 (pp. 202-203), TRC (08/05/85, 11/21/85), SRP (633-635, 1420-1423, 1763-1773, 2082-2119).

4.2 DERIVATION OF NEW GUIDELINES

Few guidelines or standards directly relevant to the types of residential exposure (inhalation of air, contact with soil) that are of primary concern in the EDA have been established by State or Federal health or environmental agencies. However, there are a number of guidelines or standards which, although not directly relevant, might be used as a starting point for calculation of values that could be applied in the EDA. For example, Threshold Limit Values (TLVs), derived by the American Conference of Governmental Industrial Hygienists (ACGIH), identify limits for airborne concentrations of toxic

chemicals in the workplace. In principle, these TLVs might be "adjusted" to derive a new value that would apply under residential conditions.

This approach was judged to be inappropriate for two reasons. First, there is no generally accepted procedure for making this adjustment, and any resulting value would be subject to debate and controversy. Second, any such extrapolation performed by the TRC would bypass the necessary and proper scientific, administrative, and public reviews that are involved in establishing guidelines and standards. For these reasons, any extrapolation from a guideline or standard not expressly derived to apply to residential exposures was judged to be inappropriate.

References for Section 4.2: 87, 101, PR-1 (pp. 38-45, 227-268), PR-2 (Sect. 2.1, 2.3), PR-4 (Sect. 2.3.2), TRC (08/05/85), SRP (1420-1423, 1434-1438, 1509-1539, 1891-1919).

4.3 RISK ASSESSMENT

Risk assessment is often used to estimate the magnitude of the human health risk at a chemical waste site. The risk assessment process includes three basic steps: first, the concentration of chemicals in the environment is determined; second, the amount of exposure (dose) for individuals who live or work in the area is estimated; and third, the health consequences of this exposure are predicted, based on available toxicological dose-response data.

However, this process is limited by a number of factors. First, it is usually difficult to identify and quantify all toxic chemicals in all media (air, soil, water), especially at a complex site such as Love Canal where many different types of waste (at least 200 different chemicals have been identified) have been deposited. Second, even if the identity and concentration of all toxic chemicals were known, there is insufficient toxicity data on many chemicals to predict the likely human health consequences of exposure. Further uncertainty is added by possible interactions among multiple chemicals, about which there is currently only limited information and understanding. Finally, the risk assessment process depends on data that are subject to change as new toxicological or epidemiological studies are performed. Consequently, a habitability decision based on even the best-performed risk assessment might subsequently have to be revised as a result of new toxicological data.

For all of these reasons, standard risk-assessment methodology was judged to be inadequate for evaluating the habitability of the EDA.

References for Section 4.3: 3, 24, 51, 82 (Appendix 7, pp. 7-4 to 7-8), PR-1 (pp. 38-45), PR-4 (Sect. 2.1.2, 2.3.2), TRC (07/23/85, 08/05/85), SRP (108-114, 568-577, 709-712, 1389-1410, 1473-1476, 1552-1566, 1683-1684).

4.4 HEALTH STUDIES

Another approach considered was to study the health status of current residents in the EDA to determine if they have an increased incidence of any chemical-related diseases or symptoms. However, experience has shown that it is very difficult to detect the effects of exposure to low-level environmental pollution in small population groups. This is because there are normally large variations in the prevalence of symptoms and diseases in different groups of people, and usually only large differences can be detected as statistically significant effects. In addition, when a difference is detected, it may be difficult to determine whether the cause is related to chemicals in the environment, the workplace, or the home, or to some other reason. Health studies of this sort performed in 1978, when the population in the EDA was large, provided no definitive evidence of chemical-related health effects, and any such studies done now, when the residential population is much smaller, would almost certainly not be sufficiently sensitive to detect any health effects that might exist.

It should be noted that health studies based on past residents of the EDA (people who were residents prior to remediation but who no longer live in the EDA) would not provide useful information about any possible health risks that might currently exist in the EDA. Likewise, any study of the future health status of current residents or of future residents (if rehabitation occurs) cannot be part of the current decision-making criteria.

A variation to studying the health of current residents would be to measure the levels of chemical pollutants in the fluids or tissues of EDA residents. However, this approach is limited by the same problem of variations among individuals and among groups of people as noted previously. In addition, while any above-average concentrations would indicate above-average exposure, this finding would not necessarily imply that any adverse health

effects would result or that emissions from Love Canal had caused the above-average exposures.

For these reasons, neither of these approaches was judged to be adequate to serve as the primary basis for evaluating the habitability of the EDA. However, based on recommendations in the Habitability Criteria document, the NYSDOH will determine whether Love Canal residents have experienced an increased incidence of adverse health outcomes relative to populations from comparable areas in the United States. To this end, the NYSDOH is updating the registry of people who live or have lived in the Love Canal area.

References for Section 4.4: 1, 2, 3, 15, 20, 31, 40, 41, 42, 44 (pp. 11-17), 45 (pp. 16-32), 46, 49, 50, 52, 56, 57, 58, 64, 65, 66, 67, 69, 86 (pp. 32-33, Appendix 7, pp. 7-11 to 7-12), PR-1 (pp. 461-471), PR-2 (Sect. 2.11), PR-3 (p. 204), TRC (11/21/85, 12/03/87), PR-5 (551-562), SRP (47-65, 114-119, 138, 176-300, 313-315, 380-381, 625-633, 741-765, 862-925, 1015-1102, 1215-1254, 2131-2132, 2161-2162).

4.5 TIME TRENDS IN POLLUTION LEVELS

Another approach considered was to determine if chemical contamination of the environment had been reduced by the remedial activities (as described in Section 1.3) at the site. This approach has two serious limitations. First, adequate historical quantitative data on chemical levels in the EDA are limited, so identifying and quantifying any time-dependent changes that were present would be difficult. Second, even if the data did show a reduction in contaminant levels over time, this finding would not establish whether present levels are higher than levels in other comparable areas of the Niagara Frontier or whether present levels are acceptable. Therefore, this approach was judged to be inadequate.

References for Section 4.5: 86 (Appendix 7, pp. 7-3 to 7-4), SRP (107-108, 1970)

4.6 COMPARISON OF THE LOVE CANAL FACILITY TO STATE-OF-THE-ART FACILITIES

Another approach considered was to review the design features and performance data for the Love Canal leachate treatment facility and to compare them to a state-of-the-art facility meeting all existing regulations. This approach was deemed to be inadequate, since the design and operation of each waste treatment plant depends on site-specific variables such as type, number, and quantity of contaminants present, hydrogeological characteristics of the site, and so on. In addition, this approach would not address whether any residual contamination exists in the EDA that was deposited prior to site remediation or whether such contamination would constitute an unacceptable risk.

References for Section 4.6: 86 (Appendix 7, pp. 7-12 to 7-13), SRP (132-137)

4.7 COMPARISON OF THE EDA TO INHABITED URBAN AREAS

As discussed in Section 3.2 (Consideration of "Background" Chemicals), the basic objective of the habitability study was to determine whether any chemicals from Love Canal have migrated or have been transported to the EDA, and not to evaluate the possible significance of background chemicals from other sources. An approach well-suited to this objective is comparison of chemical levels in the EDA with those in one or more areas that are similar to the EDA, but are not affected by a chemical waste site. The comparison approach is based on the assumption that inhabited residential neighborhoods that meet public health and housing codes and are not affected by a chemical landfill are habitable. Thus, data on environmental levels of chemicals collected from the comparison areas will correspond to "normal" or habitable conditions that, when compared to similar measurements in the EDA, will provide an indication of whether EDA neighborhoods and homes are or are not "significantly different," with respect to contamination, from those in comparable western New York communities. While this approach is designed to determine whether the EDA is uninhabitable due to contamination by chemicals that migrated or were displaced from the Love Canal, it cannot provide absolute assurances that the EDA is risk free.

Although the implementation of a comparative approach is not without some difficulties (see Section 6.0), this approach specifically addresses the impact of the Love Canal site on the EDA. In addition, interpretation of the results does not depend on judging what level of additional environmental contamination or risk is or is not acceptable. Consequently, the comparison approach was selected as the core of the habitability decision-making process.

References for Section 4.7: 3, 86 (pp. 8-13, Appendix 7, pp. 7-13 to 7-14), PR-2 (Sect. 2.1), PR-4 (Sect. 2.5.2), TRC (04/11/85, 07/23/85, 08/05/85, 10/07/85, 11/21/85), PR-5 (354-368), SRP (109-112, 150-153, 470-474, 876-883, 1256-1259, 1411-1421).

4.8 SUMMARY OF APPROACH SELECTED

The approach selected for evaluating the habitability of the EDA consists of two phases. First, relevant Federal or New York State standards, criteria, or guidelines for chemicals in environmental media to which residents and potential residents may have significant exposure will be used to assess the possible hazard of habitation of the EDA. Second, because applicable and relevant standards, criteria, or guidelines are not available for residential air and soil for most of the chemicals identified thus far in the Love Canal and the EDA, a comparison methodology will also be used to assess the habitability of the EDA. This approach involves comparison of environmental sampling data from the neighborhoods and residences in the EDA with results from similar inhabited communities in western New York not affected by a chemical landfill.

5.0 APPLICATION OF RELEVANT STANDARDS, CRITERIA, OR GUIDELINES

The first phase in the Habitability Study was comparison of chemical concentrations in the EDA with relevant Federal or New York State standards, criteria, or guidelines. A standard, criterion, or guideline was considered relevant if based on residential exposure conditions similar to those in the EDA. A search was undertaken to identify all standards, criteria, or guidelines that meet this definition. The results are summarized below.

5.1 AIR

National ambient air quality standards exist for six pollutants: ozone, nitrogen oxides, sulfur dioxide, carbon monoxide, lead, and suspended particulates. However, none of these pollutants are suspected of being an emission of concern from the Love Canal site, so none of these standards are useful in evaluating the effect of the waste site on ambient air quality in the EDA.

The State of New York has established a number of guidelines termed Acceptable Ambient Levels (AALs). However, these values do not specify acceptable concentrations of chemicals in ambient air; rather, they specify the maximum *increment* in airborne chemical levels permitted as a consequence of emissions from any specific industrial source. Therefore, these values are not relevant indices of ambient air quality in the EDA.

As noted previously, there are many guidelines for airborne levels of toxic chemicals in the workplace, derived by organizations such as the ACGIH or the Occupational Safety and Health Administration. However, these values are intended to apply to the workplace and are designed to protect healthy adult workers exposed for 8 hours per day, 5 days per week. They are not intended to apply to other populations (children, the aged, pregnant women) or to conditions of continuous exposure. Consequently, they are not directly relevant to the EDA.

In summary, no existing relevant guidelines or standards were located that could be used to evaluate ambient air quality in the EDA.

References for Section 5.1: 87, PR-1 (pp. 227-268), PR-3 (pp. 57-59), SRP (2082-2119)

5.2 WATER

The EPA Office of Drinking Water and the State of New York have promulgated a number of guidelines or standards that apply to human ingestion of drinking water. However, the drinking water that supplies the EDA and other regions of Niagara Falls is drawn from the Niagara River, not from a location near the Love Canal site. Consequently, although it is appropriate that drinking water supplied to the EDA meet existing standards, there is no reason to believe that the quality of this drinking water is affected by the Love Canal site.

The EPA has also published a number of values termed Ambient Water Quality Criteria. These values are intended to protect humans who ingest surface water, ingest fish taken from the surface water, or both. The only water in the EDA to which these criteria could apply are Bergholtz and Black Creeks. However, because these creeks are to be fully remediated as part of the remedial plan at the site, evaluation of the creeks by use of these criteria was not considered to be necessary.

References for Section 5.2: 87, SRP (2082-2119)

5.3 SOIL

No Federal or New York State standards define acceptable concentrations of toxic chemicals in residential soil. However, a value of 1 (ppb) (1 μg/kg) for TCDD in accessible residential surface soils has been identified as a level of concern by the CDC. This concentration value is estimated to pose an excess lifetime risk of cancer of approximately 10^{-5} to 10^{-8} for a resident who inhales, ingests, and has dermal contact with typical amounts of soil. Because this value is based on estimates of exposure typical of a residential area, it is directly applicable to the EDA.

References for Section 5.3: 87, 113, PR-1 (pp. 227-268), TRC (10/07/85), SRP (16-17, 938-939, 2112-2113)

5.4 SUMMARY

Only one guideline or standard (that for TCDD in soil) was identified that was relevant and useful for evaluating the acceptability of chemical levels in the EDA. Other guidelines and standards were not relevant, either because they do not apply to the residential exposure conditions in the EDA or because they relate to chemicals that are not associated with the Love Canal site.

6.0 IMPLEMENTATION OF THE COMPARATIVE APPROACH

The objective of the comparative approach was to determine if chemical pollutants from Love Canal occur in the EDA at concentrations significantly greater than the concentrations of these chemicals in comparable residential areas not affected by a chemical waste site. Implementation of this approach required answers to three basic questions:

- What environmental media will be compared?
- What chemicals will be compared?
- What areas will be compared?

The approaches selected for answering these questions are detailed below.

6.1 SELECTION OF ENVIRONMENTAL MEDIA FOR COMPARISON

The principal consideration in choosing appropriate comparison media was the likelihood that the medium is a significant exposure route in the EDA. This depends on the extent of human contact with the medium and the likelihood that the medium is contaminated with chemicals from Love Canal. Application of these criteria to each of the possible media is described below.

6.1.1 Air

If ambient (outdoor) air is contaminated with chemicals from Love Canal, many or all residents of the EDA will be exposed. Outdoor air might be affected by emissions from the site or the treatment plant, or possibly, by volatilization from contaminated soils. Indoor air could, in some cases, also be affected by chemicals volatilizing from subsurface soils into basements or crawl spaces. While this process might affect only a limited number of residences, it could result in indoor air exposure levels considerably higher than in ambient air. On this basis, both indoor and outdoor air were selected as comparison media.

6.1.2 Soil

Previous studies have revealed that soil in the immediate vicinity of Love Canal was contaminated by a variety of chemicals. In addition, contaminated soil from close to the Canal was used in at least one case as fill material at another location in the EDA (the 93rd Street School) and may have been used at other locations as well. Most humans are exposed to soil through incidental ingestion of soil from the hands or on food, from inhalation of soil particles suspended in air, or by dermal contact with soil, especially during activities such as gardening, excavation work, or children playing outdoors. On this basis, soil was selected as an appropriate comparison medium.

6.1.3 Surface Water

Surface water was excluded as a sampling medium for the Habitability Study because soil sampling was judged to be preferable and more meaningful. When present, standing surface water is chiefly the result of precipitation that has not evaporated or been absorbed into the soil. Chemical levels measured in standing surface water would be a reflection of those in the soil on which the surface water lies. Also, soils will contain all contaminants present, while surface water will contain primarily the water-soluble compounds. Finally, human contact with standing surface water is usually limited and intermittent.

The only permanent bodies of surface water in the EDA are Bergholtz and Black Creeks. Sediments in some parts of the creeks were previously contaminated by discharges from storm and sanitary sewers. However, because the remedial plan for the EDA specifies that these creeks will be excavated and remediated, the creeks were not selected as comparison media.

6.1.4 Shallow Ground Water and Basement Seepage

Shallow (subsurface) ground water and seepage found in basement sumps were not selected as environmental sampling media, though it was recognized that, should contaminated water leak into basements, it would settle in sumps, and volatile chemicals could escape into the air. However, sumps also serve as a collection point for spilled domestic products, and these chemicals could obscure measurements of Love Canal chemicals. For purposes of the Habitability Study, indoor air sampling in basements was judged

to be the most direct and relevant index of exposure to Love Canal contaminants that may be transported through shallow ground water into basements.

6.1.5 Deep Ground Water

Ground water is not currently used as a source of domestic water supply in the EDA, and it is unlikely to be used for this purpose in the future. Therefore, ground water does not represent an exposure source for EDA residents, and it was excluded as a comparison medium for this reason.

Periodic ground water monitoring in and around the Canal is included as one of the special provisions required by the Habitability Criteria and is an integral part of the remedial program. Monitoring wells of varying depths are currently located around the Love Canal site at varying distances from the Canal. Monitoring of ground water from these wells will be continued into the future.

References for Section 6.1: 21, 22, 32, 48, 61, 86 (pp. 26-28, Appendix 11), 114, PR-1 (pp. 280-297, 368-377), PR-2 (Sect. 2.5), PR-3 (pp. 16-19), PR-4 (Sect. 2.6.1 to 2.6.5), TRC (02/21/85, 03/14/85, 04/11/85), SRP (79-80, 302-304, 333-377, 408-410, 455-458, 615-616, 826-838, 876-883, 1582-1589, 2053-2072, 2236-2275)

6.2 SELECTION OF COMPARISON CHEMICALS

Given that the comparison of the EDA to other areas would be made on the basis of concentrations of chemicals in soil and air, it was necessary to select the specific chemicals that would be measured. One possibility was to analyze for each chemical suspected of having been deposited in Love Canal. However, this list is rather large (a minimum of 200 different chemicals and perhaps a great many more), and analyzing a large number of samples for each of these chemicals would have been very difficult. Indeed, adequate analytical techniques with the necessary sensitivity and specificity do not exist for many of the chemicals, especially in soil. Thus, it was a practical necessity that analyses be performed for only a subset of all the chemicals that are known or suspected to have been deposited in Love Canal. Three basic subsets of chemicals were considered, as described below.

6.2.1 All Love Canal Chemicals for Which Adequate Analytical Techniques Exist

The first possibility was to select chemicals solely on the basis of whether or not it is possible to perform reliable chemical analyses in soil and air. This "broad-brush" approach had the advantage that it would provide the maximum amount of information concerning the levels and location in the EDA of environmental pollutants from the Love Canal. However, there were three significant disadvantages to this approach. First, it would still have been very time-consuming and costly to perform analyses of sufficient specificity and reliability, that also had a sufficiently low detection limit for a large number of different chemicals in the samples. Second, when many different variables are measured and compared among multiple groups, it is a near statistical certainty that some differences among the groups will appear to be real when, in fact, they are a consequence of random variation. Third, many of the chemicals in the Love Canal are also widely distributed in the environment, and detection of these chemicals in the EDA would not distinguish whether they arose from Love Canal or other sources. Based on these considerations, it was concluded that this approach should not be employed and that a more limited subset of chemicals should be selected for analysis.

6.2.2 Most Toxic Chemicals

The second possibility was to select a subset of chemicals on the basis of their toxicity. This approach assumes that if human health risk from the most toxic chemicals is minimal, then health risk from other less toxic chemicals is also minimal. However, this may not necessarily be so, especially if large numbers and/or high concentrations of the less toxic chemicals are present. In addition, while it may be possible to select a list of the most highly toxic Love Canal chemicals based on current knowledge, that list might later prove to be inadequate, due to discovery of previously unrecognized adverse health effects of other chemicals at the site or to the discovery of previously unrecognized toxic chemicals in Love Canal. For these reasons, this approach was considered inadequate.

6.2.3 Indicator Chemicals

A third option was to select a group of chemicals based on their ability to migrate from Love Canal into the EDA and to persist there. This approach

is based on the concept that the location of the most highly mobile chemical present in a landfill will mark the outer boundary of any chemical migrations from the site. This approach had the advantage that attention could be focused on only a few specific chemicals, allowing optimization of analytical detection limits, accuracy, and reliability, and this in turn would reduce statistical difficulties in data interpretation. In addition, the approach is inherently conservative, since elevated levels of an indicator chemical at a location do not prove that any chemicals of health concern are also present at that location. For these reasons, this approach was selected as the most appropriate.

6.2.4 Indicator Chemical Selection Criteria

Based on the general concept of indicator chemicals as described above, the following characteristics were judged to be important properties of any LCIC selected.

6.2.4.1 Presence in Love Canal. If a chemical is to serve as a marker of chemical migration from a landfill, it is evident that the chemical must have been deposited in the landfill. For this reason, only chemicals that are known to or likely to have been disposed of in Love Canal were considered. Detection of a chemical in the present-day leachate from the site (that is, in the influent to the treatment plant) was a useful but not essential means of confirming the prior disposal of a chemical in the Love Canal landfill.

6.2.4.2 Migration Potential. As discussed above, a key characteristic of a suitable indicator chemical is a high migration potential in the medium of concern. For soil, migration potential correlates with good water solubility and relatively low adherence to soil particles. For air, it correlates with adequate volatility to ensure significant escape into air.

6.2.4.3 Analytical Suitability. It is important that for each indicator chemical, analytical techniques exist that have detection limits low enough that levels in the EDA and comparison areas can be measured. One way to ensure this was to focus on chemicals that were previously detected at least once in the EDA, since this is direct evidence that available methods are adequate to detect the levels likely to be encountered in the EDA. In addition, the analytical method for the chemical must be specific (i.e., able to

distinguish the indicator from other chemicals) and reliable (i.e., able to give reproducible results within acceptable limits of variation).

6.2.4.4 Environmental Persistence. One concern in the EDA is that chemicals that reached the area in the past (before remediation) may still persist. For this reason, indicator chemicals must be relatively stable in the environment, resisting degradation by both chemical and biological pathways. This characteristic ensures that they will adequately indicate past as well as current sources of exposure.

6.2.4.5 Specificity (Ubiquity). As discussed in Section 3.2 (Consideration of "Background" Chemicals), one of the factors that complicates the comparative approach is that chemicals in the EDA may have arisen either from the Love Canal or from outside sources, or both. The problem posed by "ubiquitous" chemicals (those that are common in the environment) is twofold: first, the presence of a substantial background level of a chemical in the EDA greatly diminishes the ability to detect a small increase due to an emission from Love Canal; and second, variations in the level of background chemicals between the EDA and the comparison areas can lead to faulty conclusions. For example, the level of a ubiquitous chemical might be higher in the EDA than the comparison area because the local background emission rate is high, and not because of emissions from Love Canal. This situation would lead to the conclusion that the EDA was affected by the Canal when it was not (a false positive). Conversely, if the background level of a ubiquitous chemical were higher in the comparison area than in the EDA, this could mask the presence of emissions in the EDA that did derive from the Canal (a false negative).

Because of these problems, a desirable property of indicator chemicals is that they are not likely to be present in the environment (either the EDA or the comparison areas) as a result of emissions from sources other than Love Canal. It is important to reemphasize that this does not mean that ubiquitous chemicals originating from the waste site are of any less concern than non-ubiquitous chemicals, only that ubiquitous chemicals are not the best choice to determine the extent of any migration.

6.2.4.6 Evidence of a Gradient. One way to ensure that the chemicals selected as indicators are appropriate markers of migration from the landfill is to show that the chemical has a decreasing gradient of environmental concentration as a function of distance from the site. This characteristic is

expected of chemicals moving away from the waste site but is not expected of chemicals which reach the EDA by migration from other locations.

6.2.4.7 Correlation Between Chemicals. An additional means of ensuring that chemicals selected as indicators do, in fact, reflect emissions from the Love Canal is to show that their levels tend to vary in concert (i.e., they are correlated). This property is expected of two or more chemicals arising from the same site and migrating by the same pathway but would not be expected of chemicals arising from different background sources.

6.2.4.8 Optimal Number of LCICs. There are two opposing considerations that influence the optimum number of indicator chemicals to select. On one hand, choosing several LCICs provides desirable redundancy and reduces the chances that random fluctuations in LCIC levels could lead to a faulty conclusion. On the other hand, choosing a large number of LCICs greatly increases the statistical chance of obtaining a false positive result. Based on these two considerations, it was concluded that at least 2 but less than 10 LCICs should be selected for each comparison medium.

6.2.5 Selection of Indicator Chemicals

The indicator chemical selection criteria described above were applied in a series of steps, as shown in Figure 6-1. First, a list of all chemicals known or likely to have been deposited in Love Canal was assembled from available historical records. This list of chemicals is shown in Table 6-1. Next, a number of these chemicals were excluded because of their low mobility or their lack of stability in the environment, or because they are ubiquitous. The chemicals that were excluded and the reasons for their exclusion are shown in Table 6-2. For the remaining chemicals, historical monitoring data that met quality assurance reviews were reviewed to determine if the chemical had been detected at least once in either the air or the soil of the EDA, and if so, whether there was evidence of a decreasing concentration gradient from Rings I and II to the EDA. This analysis is summarized in Table 6-3. Chemicals that had been detected in the EDA but whose concentrations were either lower or nondetectable in Rings I and II (a reverse gradient) were not considered, since this suggests that some source other than the Canal is more important.

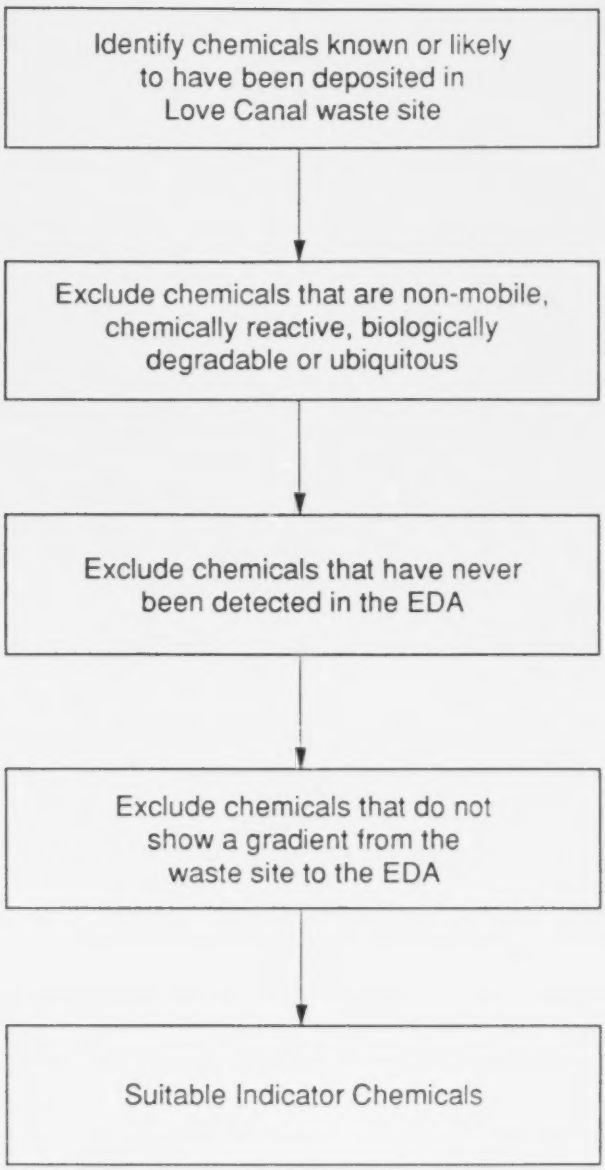
Identify chemicals known or likely to have been deposited in Love Canal waste site
Exclude chemicals that are non-mobile, chemically reactive, biologically degradable or ubiquitous
Exclude chemicals that have never been detected in the EDA
Exclude chemicals that do not show a gradient from the waste site to the EDA
Suitable Indicator Chemicals

Figure 6-1
LCIC SELECTION PROCESS

Table 6-1

CHEMICALS LIKELY TO HAVE BEEN DEPOSITED AT LOVE CANAL

Halogenated Organics

- Carbon Tetrachloride
- Chloroform
- 1,1-Dichloroethylene
- Trichloroethylene
- Tetrachloroethylene
- Hexachloroethane
- Hexachlorobutadiene
- Hexachlorocyclopentadiene

Benzene and Derivatives

- Benzene
- Monochlorobenzene
- 1,2-Dichlorobenzene
- 1,3-Dichlorobenzene
- 1,4-Dichlorobenzene
- 1,2,4-Trichlorobenzene
- 1,2,3,4-Tetrachlorobenzene
- 1,2,4,5-Tetrachlorobenzene
- Pentachlorobenzene
- Hexachlorobenzene
- Benzoic acid
- Benzoyl chloride
- Benzyl chloride
- Benzal chloride
- Benzotrichloride

Phenols

- 2,4-Dichlorophenol
- 2,4,5-Trichlorophenol
- 2,4,6-Trichlorophenol
- Pentachlorophenol

Toluene and Derivatives

- Toluene
- 2-Chlorotoluene
- 4-Chlorotoluene

Naphthalene and Derivatives

- Naphthalene
- Chloronaphthalenes
- Dichloronaphthalenes
- Trichloronaphthalenes

Acids and Derivatives

- Acetic acid
- Acetyl chloride
- Acetic anhydride

Pesticides and Related Products

- α-BHC
- β-BHC
- γ-BHC
- δ-BHC

Metals

- Arsenic
- Antimony
- Chromium
- Copper

Other

- Carbon disulfide
- Dioxin (TCDD)

Source: Adapted from *Love Canal Emergency Declaration Area: Proposed Habitability Criteria* (1986)

Table 6-2

LOVE CANAL CHEMICALS EXCLUDED AS INDICATOR CHEMICALS

Reason for Exclusion	Chemicals Excluded
Chemical Reactivity	Acetyl chloride Acetic anhydride Benzoyl chloride Benzyl chloride Benzal chloride Benzotrichloride
Biological Degradability	Acetic acid Benzoic acid Dichlorophenol
Ubiquity	Benzene 1,4-Dichlorobenzene Chloroform Trichloroethylene Toluene Naphthalene Carbon disulfide Tetrachloroethylene 1,1-Dichloroethylene Hexachloroethane
Low Migration Potential	Arsenic Antimony Copper Chromium TCDD Hexachlorobenzene Trichloronaphthalenes Hexachlorobutadiene Hexachlorocyclopentadiene

Source: Adapted from *Love Canal Emergency Declaration Area: Proposed Habitability Criteria* (1986)

Table 6-3

EVALUATION OF CHEMICALS BASED ON DETECTION AND GRADIENT CRITERIA

Class	Chemical	Air		Soil	
		Detected In EDA	Decreasing Gradient	Detected In EDA	Decreasing Gradient
Solvents	Carbon tetrachloride	Yes	No	Yes	No
Benzenes	Monochlorobenzene	Yes	Yes	Yes	Yes
	1,2-Dichlorobenzene	Yes	No	Yes	Yes
	1,3-Dichlorobenzene	No	NA	No	NA
	1,2,4-Trichlorobenzene	No	NA	Yes	Yes
	1,2,3,4-Tetrachlorobenzene	Yes	No	Yes	Yes
	1,2,4,5-Tetrachlorobenzene	No	NA	No	NA
	Pentachlorobenzene	Yes	No	No	NA
Phenols	2,4,5-Trichlorophenol	No	NA	No	NA
	2,4,6-Trichlorophenol	No	NA	No	NA
	Pentachlorophenol	No	NA	Yes	No
Toluenes	2-Chlorotoluene	Yes	Yes	No	NA
	4-Chlorotoluene	Yes	Yes	No	NA
Naphthalenes	Chloronapthalenes	No	NA	Yes	Yes
	Dichloronapthalenes	No	NA	No	NA
Pesticides	α–BHC	No	NA	Yes	Yes
	β–BHC	No	NA	Yes	Yes
	γ-BHC	Yes	No	Yes	Yes
	δ-BHC	No	NA	Yes	Yes

NA = Not applicable, since chemicals that were never detected in EDA were not considered further

Source: Adapted from *Love Canal Emergency Declaration Area: Proposed Habitability Criteria* (1986)

It was originally expected that a large number of candidate LCICs would remain after this stage of the selection procedure and that application of the correlation criterion would be needed to choose a suitable subgroup. However, application of the criteria above served to reduce the list of candidate LCICs to a reasonable number, so a correlation between chemicals was taken to be desirable, but not essential. The chemicals that met the selection criteria were:

- Air LCICs

  Chlorobenzene
  2-Chlorotoluene
  4-Chlorotoluene

- Soil LCICs

  Monochlorobenzene
  1,2-Dichlorobenzene
  1,2,4-Trichlorobenzene
  1,2,3,4-Tetrachlorobenzene
  2-Chloronaphthalene
  BHCs (β, γ, total)

In order to obtain preliminary information on the typical levels and degree of variation in soil LCIC concentrations, a pilot soil sampling study was carried out in the EDA and two comparison areas in the Buffalo area (see Section 6.3, below). The results of this study revealed that monochlorobenzene did not occur at measurable concentrations in any of the samples from the EDA or the comparison areas. Since analysis of soil for monochlorobenzene required a separate sample preparation procedure from that used for the other soil LCICs, it was decided to drop monochlorobenzene from the list of soil LCICs. Subsequent improvements in the analytical methods for soil LCICs (see Volume III) allowed two additional BHC isomers (α, δ) to be added, and so each was employed as a soil LCIC. Use of the four BHC isomers replaced the need for total BHC.

A pilot study was also performed to obtain preliminary data on air LCIC levels and to assess the suitability of two alternative analytical instruments: a laboratory-based gas chromatograph coupled to a mass spectrometer (GC/MS) and a mobile mass spectrometer--mass spectrometer termed the

Trace Atmospheric Gas Analyzer (TAGA). There was close agreement between the two instruments on blanks, check samples, and test samples. The TAGA was selected for use in the full-scale Habitability Study because it yields results in real time and can be used to seek out the source of any LCICs detected in a residence.

Since the TAGA does not employ a chromatographic column, it does not distinguish between isomeric forms of chemicals. Therefore, 2-chlorotoluene and 4-chlorotoluene were combined, and total chlorotoluene was taken as an appropriate air LCIC.

The pilot study indicated that very few of the test samples contained measurable levels of any air LCICs. For indoor air in occupied homes, only 1 in 30 samples from the EDA and 1 in 31 from the comparison areas had measurable levels of chlorotoluenes. No detectable levels of chlorobenzene or chlorotoluenes were observed in samples from 33 unoccupied houses in the EDA or from outdoor air in either location.

Because the air LCICs were detected so infrequently, it was concluded that any measurable concentration of LCICs in the EDA should be considered significant and that analysis of air in the comparison areas was not required.

References for Section 6.2: 8, 9, 11, 45, 86 (pp. 28-31, Appendix 9), PR-1 (pp. 88-226, 378-386), PR-2 (Sect. 2.4, Appendix 2), PR-3 (pp. 10-13, 30-33, 87-88, 117-122, 212-250), PR-4 (Sect. 2.4.1 to 2.4.6), TRC (02/21/85, 03/14/85, 11/21/85, 09/04/86), PR-5 (354-368), SRP (594-615, 826-838, 1204-1214, 1567-1589, 1654-1687, 2236-2275)

6.3 SELECTION OF COMPARISON AREAS

The comparison approach to determining the relative habitability of the EDA is based on a comparison of environmental sampling results from the neighborhoods and homes of the EDA with those from similar inhabited communities not affected by a chemical landfill. This method relies on the comparison area to provide data that corresponds to "normal" or habitable conditions and that, when compared to similar measurements in the EDA, can provide an indication of whether EDA neighborhoods and homes are different from those in other western New York communities. Critical to the

success of this approach are the criteria and methodology for selection of the comparison areas.

6.3.1 Selection Criteria

In principle, an ideal comparison area would be identical to the EDA in all respects except for the presence of a chemical waste site. A number of selection criteria were established in order to guide the search for appropriate comparison areas and to ensure that the areas selected are as similar to the EDA as possible. These selection criteria are described below.

6.3.1.1 General Location. The Niagara Frontier of western New York is characterized by a relatively high density of chemical manufacturing and other industrial sites, and halogenated organic compounds are commonly found in the air in this area. Consequently, it was important that the comparison areas be selected from within this industrialized area to ensure that background levels of environmental chemicals in the EDA are similar to those in the comparison areas. In addition, comparison areas located in the Niagara Falls/Buffalo area are likely to have meteorological and hydrogeological characteristics similar to the EDA, and nearby areas provide a familiar frame of reference for residents of the EDA.

6.3.1.2 Distance from a Waste Site. While it was apparent that a comparison area must be sufficiently far from the closest waste site so that it is not affected by the site, it was not immediately obvious what distance is adequate to meet this demand. The distances that any leaking chemicals will migrate away from a waste site depend on the nature and quantity of the chemicals present, along with the geological, meteorological, and hydrological characteristics of the site. Consequently, any single absolute distance criterion that does not consider site-specific characteristics is essentially arbitrary. Nevertheless, it was desirable to establish some sort of minimum distance criterion in order to guide the process of selecting comparison areas. Originally, a distance of at least one mile from a chemical waste site was proposed. However, initial attempts to locate comparison areas in the Niagara Falls/Buffalo area revealed that, because of the large number of known chemical waste sites in the area, there were no suitable residential neighborhoods located more than one mile from a waste site. As a result, the distance criterion was designated to require that comparison areas should

be as far as possible, but no less than one-half mile, from any known chemical landfill.

6.3.1.3 Soil and Hydrologic Characteristics. As discussed above, the fate and transport of contaminants released from a chemical landfill are determined by the chemical characteristics of the leachate and, to a great extent, by the topographical, hydrogeologic, and meteorological conditions that characterize the site. In addition, the ability to extract and detect chemicals adsorbed to soil may depend upon soil type. For these reasons, it was important to ensure that the comparison areas resemble the EDA with respect to soil type and hydrogeologic and meteorological conditions.

6.3.1.4 Housing Characteristics. Studies during the last decade have shown that indoor air quality is strongly influenced by chemical emissions from building materials and various household products. For this reason, it was important that the homes of the comparison areas and the EDA be similar. The most useful parameters available for characterizing the nature of a residential neighborhood were housing age, density, and value. Housing value, in particular, was used as a proxy for the type of house and type of living style of the residents as well. These statistics were available from the 1980 Census for each census tract in the EDA and in the surrounding areas.

If the EDA were fully populated, it would also have been important to match the EDA and comparison areas with respect to population-based characteristics such as age, sex, race, and income levels. However, since the EDA is now mostly unoccupied, such characteristics were not directly relevant to the selection process.

6.3.2 Number of Comparison Areas

Implementation of the comparison approach required selection of at least one suitable comparison area, but selecting two or more comparison areas was deemed to have some merit. The main advantage of sampling in multiple comparison areas is that more data would be obtained on typical background levels of environmental contaminants, thereby reducing statistical variations and uncertainty in the comparative process.

However, if two or more comparison areas were employed and if these comparison areas were significantly different from each other, then it was not clear how the comparison to the EDA should be made. For example, if the EDA were "as safe as" one area, but not as safe as the other, what habitability decision would be appropriate? Assuming that all comparison areas have acceptable levels of background chemicals, then it could be argued that the comparison area with the highest background levels should be used for comparison to the EDA. It was concluded that at least two comparison areas should be selected and that the sampling results from these areas would be treated as one data set for the purposes of comparison with the EDA. The data from each comparison area would be maintained separately in case separate analysis was later judged to be necessary.

6.3.3 Comparison Areas Selected

Based on the selection criteria described above, areas in western New York (Niagara and Erie Counties) were evaluated to determine their suitability as comparison areas for the Habitability Study. The first step in the process was to identify and characterize the soil types and hydrogeology found in the EDA. The State Geographical Survey of the New York State Education Department characterized EDA soils as lake silt, composed of fine to medium sand and clay. The overburden was characterized as thin bedded to massive, and in part, regularly bedded with cyclic alteration to clay and silt laminae and moderately permeable along bedding surfaces. The circumstances leading to this geological formation were offshore deposits from lakes and basins that did not require an impounding ice margin for closure and hence persisted after deglaciation.

The second step in the process was to identify areas in Niagara and Erie Counties with similar soils and to display them on a map. Chemical waste disposal sites listed in the most current New York State Registry of Sites (1984) and on the Community Right-To-Know List were located on the same map, as were census tract boundaries. Census tracts with borders one-half mile or less from known waste sites were excluded from further consideration.

The remaining tracts, all at least one-half mile from any known chemical disposal site, were then rank-ordered according to distance from the nearest site and compared to the EDA for similarity with respect to prevailing winds from

major industrial air emission sources and with respect to selected socioeconomic indicators such as age and value of housing.

Starting with census tracts that were located closest to chemical waste disposal sites, census tracts that represented the poorest match with the census tracts composing the EDA were rejected until the list was reduced to six tracts. These were Erie County tracts 38, 40, 80.02, 80.03, 101.02, and 103.

NYSDOH staff reviewed all available data and information on any chemical waste disposal sites located within 8,000 feet of these six tracts. The disposal sites were inspected to assess any potential for offsite migration that might affect the census tracts under consideration as comparison areas. Based on this review, two census tracts, 38 and 103, were excluded from further consideration because it was determined that the Scajaquada Creek flowed beneath them after receiving permitted industrial discharges.

A panel of eight individuals (two representatives from the NYSDOH, one representative from the NYSDEC, and five residents of the EDA) inspected the remaining four sites (40, 80.02, 80.03, and 101.02) for visual comparability with the EDA. Neighborhoods within each census tract were determined by panel consensus to be "acceptable" or "not acceptable," and the most suitable neighborhoods were identified for comparison to the EDA. Based on this review, neighborhoods within Tonawanda Census Tract 80.03 and Cheektowaga Census Tract 101.02 were selected as the most appropriate comparison areas.

With two comparison areas identified in the Buffalo area, a pilot sampling study was carried out to provide information on the typical levels and degree of variation in soil LCIC concentrations in the EDA and the comparison areas. This study revealed that two soil LCICs (1,2,4-trichlorobenzene and 1,2,3,4-tetrachlorobenzene) occurred at measurable levels in more than 30 percent of the samples from the EDA, but were detectable in less than 2 percent of the samples from the comparison areas. However, this pattern was not observed for any of the other soil LCICs, suggesting the possibility that these two contaminants might have reached the EDA from some local source other than the Love Canal waste site.

In order to determine whether soil contamination with 1,2,4-trichlorobenzene and 1,2,3,4-tetrachlorobenzene was widespread or restricted to the EDA, the NYSDOH collected a number of soil samples from four different

regions in the Niagara Falls area, including the EDA and one area in Buffalo. The results of this study indicated that significant differences existed between the levels of these chemicals in the sites in Niagara County (including the EDA) and the comparison site in Buffalo. This finding presented a significant complication to the implementation of the full-scale soil sampling plan. A number of alternatives were considered for addressing this problem, as summarized in Table 6-4.

Alternative 1 (no change from the original plan) was rejected because it would not allow an assessment of the effect of the Love Canal waste site on the EDA, independent of the influences of other sources of environmental pollutants in the Niagara Falls area. Alternative 2 (deletion of 1,2,4-trichlorobenzene and 1,2,3,4-tetrachlorobenzene as LCICs) was rejected because these chemicals had met all the selection criteria for LCICs, and deletion of these chemicals would render the design of the full-scale study uncertain and could become a source of public concern. Alternative 4 (replacing the original comparison areas with new areas in Niagara Falls) was rejected because the original comparison areas had been selected in accordance with the specified criteria, while the NYSDOH areas had not specifically been selected to meet the criteria.

Alternatives 3 and 5 are similar in that they retain all LCICs and the original comparison areas, while adding one or more new comparison areas in Niagara Falls. The alternatives differ only in whether all LCICs or only 1,2,4-trichlorobenzene and 1,2,3,4-tetrachlorobenzene would be measured in the Niagara Falls areas. Of these, alternative 3 (analysis for all LCICs in all comparison areas) was selected as the most appropriate.

Consequently, a search was undertaken to identify suitable comparison areas in the Niagara Falls area. Based on a review of areas in Niagara Falls near the EDA but at least one-half mile from any known chemical waste site, two neighborhoods (portions of Census Tracts 221 and 225) were selected as comparison areas. The LaSalle neighborhood (Census Tract 221) had been employed as a control area during earlier studies based on similarities of socioeconomic characteristics to the EDA, and both areas have hydrogeological characteristics similar to the EDA. If concentrations of any LCIC are found to be significantly higher in the EDA than in the Buffalo comparison areas, then the Niagara Falls comparison areas should be compared to both the EDA and the Buffalo comparison areas. The purpose of this comparison would be to determine whether the concentrations are unique

Table 6-4

ALTERNATIVE MODIFICATIONS TO SOIL LCIC COMPARISON PROCEDURE

Alternative	Comparison Areas	LCICs
1	Retain original areas	Retain all LCICs
2	Retain original areas	Delete 1,2,4-trichlorobenzene and 1,2,3,4-tetrachlorobenzene
3	Retain original areas; add new areas from Niagara Falls	Retain all LCICs
4	Replace original areas with new areas from Niagara Falls	Retain all LCICs
5	Retain original areas; add new areas from Niagara Falls	Retain all LCICs for original areas; analyze for 1,2,4-trichlorobenzene and 1,2,3,4-tetrachlorobenzene only in Niagara Falls area

Source: Adapted from *Pilot Study for Love Canal EDA Habitability Study*, Volume II (1987)

to the EDA or indicative of regional sources other than known toxic waste disposal areas.

Figure 6-2 depicts the location of the four comparison areas that were selected in relation to known chemical waste sites and to the EDA.

References for Section 6.3: 34, 84, 85, 86 (pp. 23-26) PR-1 (pp. 269-279), PR-2 (Sect. 2.6), PR-3 (pp. 13-21, 137-157, 172-175), PR-4 (Sect. 2.5.1 to 2.5.6, 2.8.1), TRC (02/21/85, 03/14/85, 04/11/85, 08/05/85, 10/07/85, 11/21/85, 01/21/87, 03/31/87, 04/10/87), PR-5 (406-410, 545-546), PR-6 (Sect. 3.0), SRP (716, 1804-1805, 1871-1891, 2164-2234)

6.4 SELECTION OF NEIGHBORHOOD BOUNDARIES

As discussed in Section 3.3 (Evaluation by Residences and Neighborhoods), the basic unit of the Habitability Study was an individual residence, but evaluating the habitability of the EDA on a neighborhood scale also seemed appropriate. In general, neighborhood boundaries may be based on geographic barriers (creeks, roads, etc.), community interactions (schools, churches, etc.), or social distinctions (income, ethnicity, etc.).

For statistical reasons, the size of the neighborhoods is also an important consideration. If a large number of small neighborhoods were demarcated, there would be a high statistical probability that one or more of the neighborhoods would, by chance variations alone, appear to be different from the comparison areas when, in fact, there was no real difference (a false positive). This problem is diminished by increasing the size (and decreasing the number) of neighborhoods, but this approach decreases the ability to detect local areas of elevated chemical levels and increases the potential of declaring a large part of the EDA uninhabitable even if only localized contamination is found.

Figure 6-3 displays a set of boundaries that divide the EDA into 13 neighborhoods. These boundaries were established by sociologists on the basis of roadway and waterway patterns, the distribution and location of housing units, and the patterns of social interactions among remaining and former residents. The 93rd Street school site in the northwest portion of the EDA was not included, since this is being evaluated separately. To reduce the

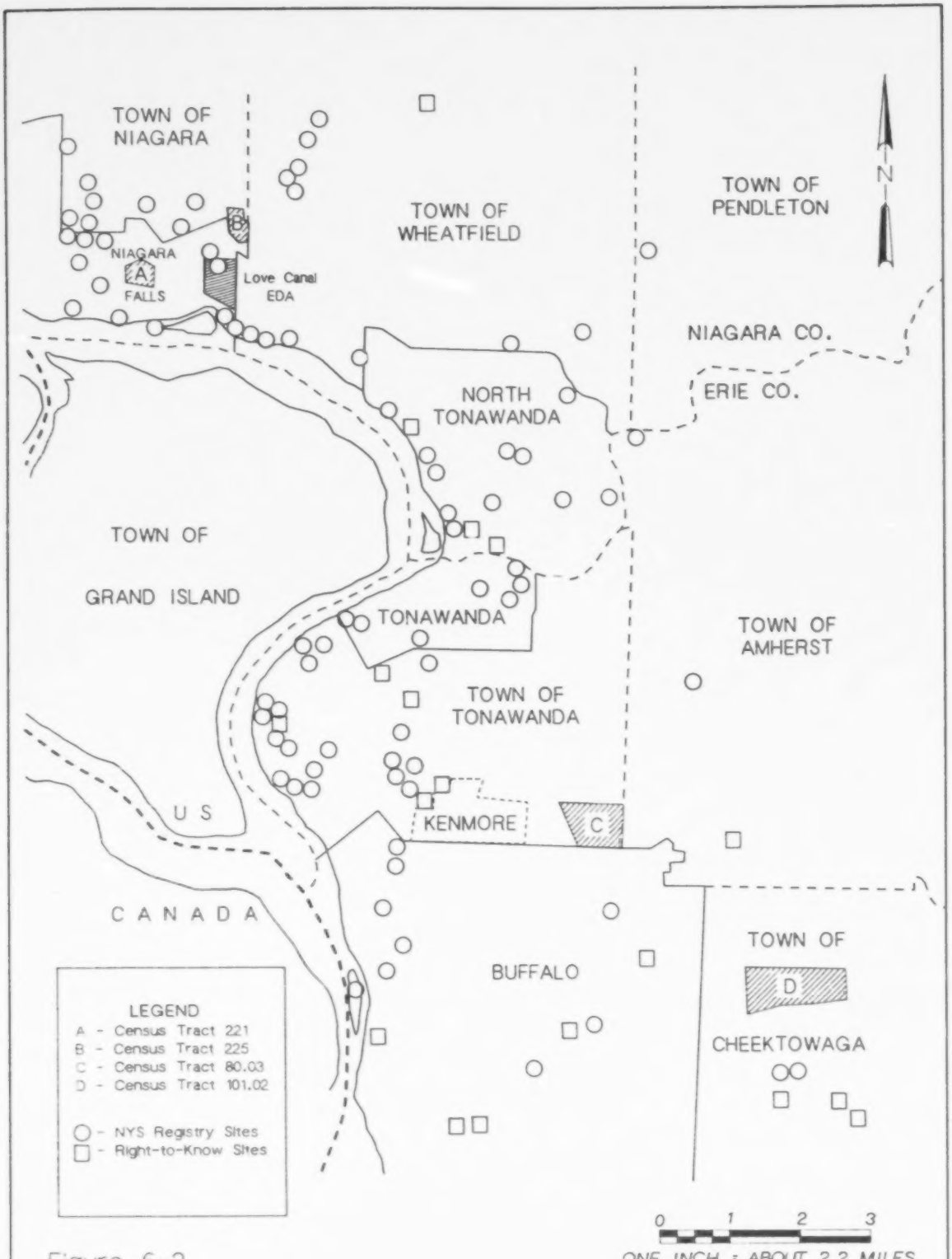

Figure 6-2

MAP OF WASTE SITES AND COMPARISON AREAS IN NIAGARA AND ERIE COUNTIES

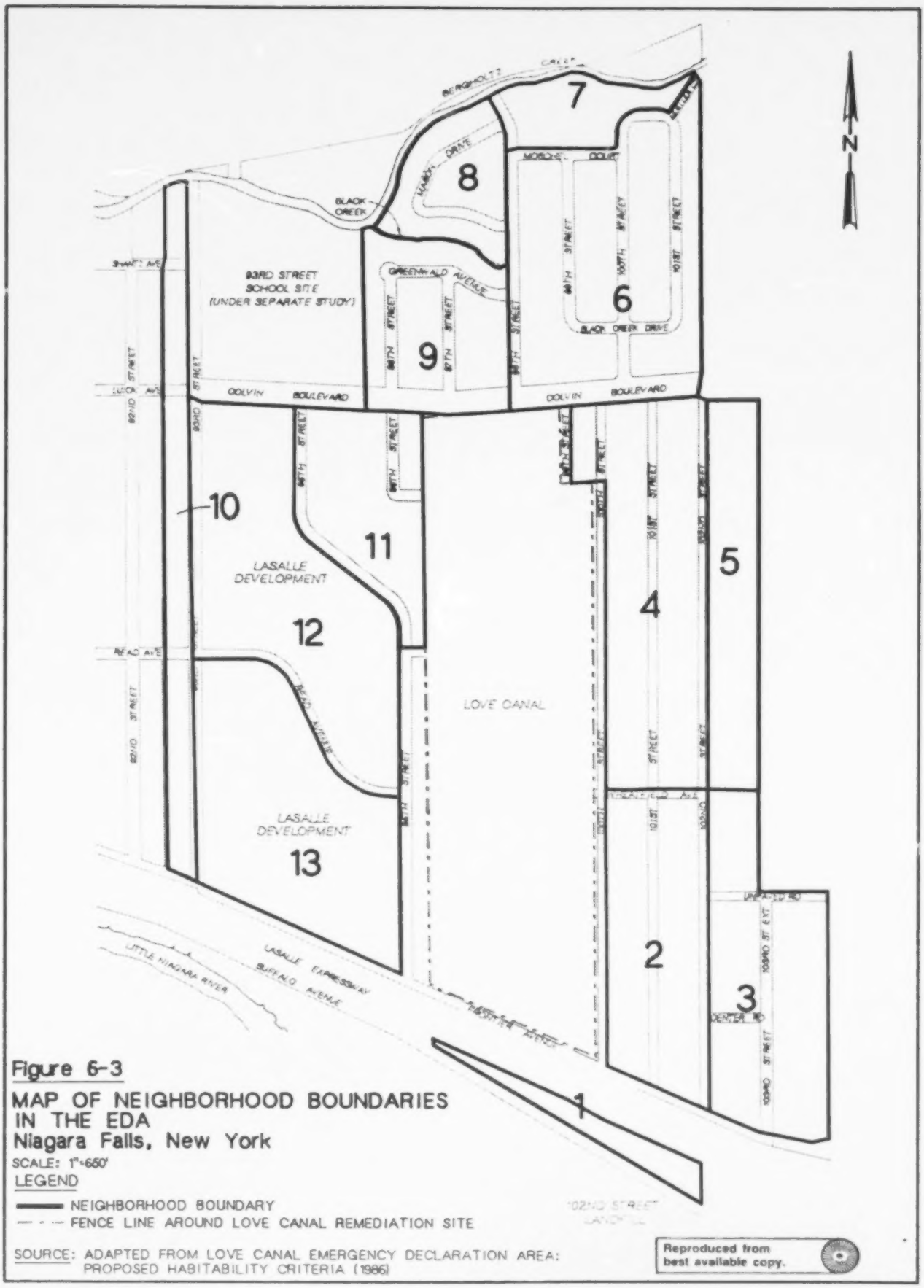

Figure 6-3

MAP OF NEIGHBORHOOD BOUNDARIES IN THE EDA
Niagara Falls, New York

SCALE: 1"=650'

LEGEND

——— NEIGHBORHOOD BOUNDARY
— - — FENCE LINE AROUND LOVE CANAL REMEDIATION SITE

SOURCE: ADAPTED FROM LOVE CANAL EMERGENCY DECLARATION AREA: PROPOSED HABITABILITY CRITERIA (1986)

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statistical chances of a comparison falsely indicating a significant difference and to reduce the range of spatial sampling densities, some of these original 13 neighborhoods were combined to yield seven sampling areas, as shown in Figure 6-4. These areas were considered to be the most appropriate a priori divisions, but the option was kept to redefine some boundaries after sampling was completed in order to minimize the impact of any areas that might be found nonhabitable and to maximize the amount of contiguous habitable area.

References for Section 6.4: 20, 86 (Appendix 8), PR-1 (pp. 386-402), PR-2 (Sect. 2.9), TRC (03/14/85, 04/11/85, 09/04/86), PR-5 (538-542), SRP (1604-1606, 1777-1783, 1806-1808, 2309-2311)

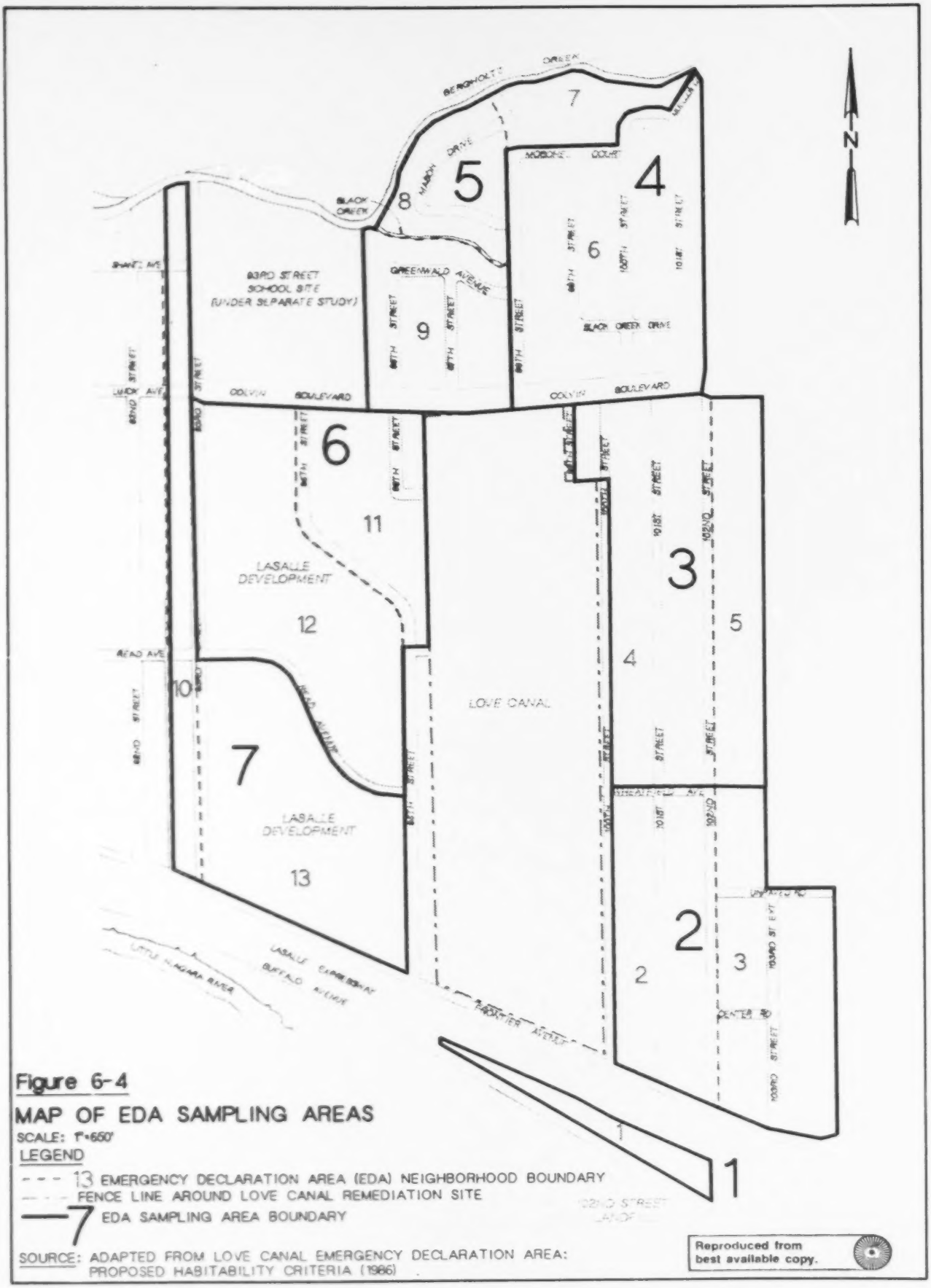

Figure 6-4

MAP OF EDA SAMPLING AREAS

SCALE: 1"=650'

LEGEND

- - - 13 EMERGENCY DECLARATION AREA (EDA) NEIGHBORHOOD BOUNDARY

— — — FENCE LINE AROUND LOVE CANAL REMEDIATION SITE

—7 EDA SAMPLING AREA BOUNDARY

SOURCE: ADAPTED FROM LOVE CANAL EMERGENCY DECLARATION AREA: PROPOSED HABITABILITY CRITERIA (1986)

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7.0 SAMPLING AND ANALYSIS PLAN

One of the major criticisms voiced by OTA regarding the original EPA/DHHS habitability evaluation was that an insufficient number of samples had been taken in the EDA and in the comparison area and that analytical methods employed may not have had sufficiently low detection limits, especially for the analysis of soil. Consequently, considerable care was taken in the data collection phase of the Habitability Study to ensure that the number of samples and the analytical detection limits would be adequate to yield an unambiguous result.

This involved development and validation of sample collection protocols, analytical methods, and quality assurance procedures. In order to test the adequacy of the sampling and analysis plans, pilot studies were performed for the analyses of LCICs both in air and in soil. These pilot studies allowed for refinements and improvements in sampling and analysis methods that were incorporated into the full-scale protocols. The details of these sampling and analysis procedures are presented in the appropriate sections of the following volumes, which describe the analysis of LCICs in air (Volume II) and soil (Volume III) and the analysis of TCDD in soil (Volume IV).

References for Section 7.0: 84, 85

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2	Pilot Cytogenetic Study of the Residents of Love Canal	Biogenics	05/14/80
3	Love Canal Emergency Declaration Area (EDA) Strategy for Determination of Habitability	Centers for Disease Control	03/00/84
4	Public Review Draft: Data Collection and Evaluation Support, Love Canal Remedial Action Plan, Draft--Phase I Work Plan	CH2M HILL	03/17/84
5	Summary of Love Canal Well Data Base Compiled by NYSDEC	NYSDEC/CH2M HILL	No Date
6	First Complete Love Canal Non-Confidential Document Citations Listing	CH2M HILL	04/24/84
7	Second Complete Love Canal Non-Confidential Document Citations Listing	CH2M HILL	06/22/84
8	List of Chemicals from Love Canal and Other Areas	CH2M HILL	06/27/84
9	Love Canal Marker Chemical Data Summary	CH2M HILL	07/25/84
10	Summary of Love Canal Environmental Data Collection Efforts by Medium	CH2M HILL	07/10/84
11	Love Canal Target Chemicals	CH2M HILL	09/06/84
12	Love Canal QA Review & Assessment Technical Memorandum No. 1 Phase A Results	CH2M HILL	10/29/84
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25	Surface Soil Sampling Protocol 2,3,7,8-TCDD at Love Canal EDA	EPA	10/26/84
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